Shell Oil Products US
Soil & Groundwater FDG
20945 S. Wilmington Avenue
Carson, CA 90810
Tel +1 310-816-2043
Email: douglas.weimer@shell.com

Via Email and Overnight Service

June 30, 2014

Samuel Unger
Executive Officer
California Regional Water Quality Control Board –
Los Angeles Region
320 W. Fourth Street, Suite 200
Los Angeles, California 90013

Re: *Former Kast Property, Case No. SCP 1230 – Submission of the Revised Remedial Action Plan and Associated Documents*

Dear Executive Officer Unger:

On behalf of Shell Oil Company and Shell Oil Products US (collectively "Shell"), the Revised Remedial Action Plan, Revised Human Health Risk Assessment ("HHRA") Report and Revised Feasibility Study are being submitted to the Regional Water Quality Control Board – Los Angeles Region ("Regional Board") today. While Shell believes the Remedial Action Plan, HHRA Report and Feasibility Study originally submitted on March 10, 2014 proposed a remedial approach that would address the environmental conditions in the Carousel neighborhood and protect the Carousel residences, Shell and its consultants have revised these documents to address the comments and directives contained in the Regional Board's April 30, 2014 letter.

These documents were prepared using well-accepted and established scientific guidance and protocols, including the guidance documents specified by the Regional Board in the Cleanup and Abatement Order for this site. The analyses contained in these documents are based on the extensive testing data from the residential properties and public rights-of-way in and adjacent to the Carousel neighborhood (including over 11,000 soil samples, 2,700 soil vapor samples and 2,400 indoor and outdoor air samples). Testing has been performed at 95% of the Carousel homes and has been completed at over 80% of the homes. While Shell continues to conduct outreach to schedule testing at the remaining homes, the extensive and robust data obtained so far provide a solid foundation upon which to base the selected remedial approach.

To summarize the findings from Shell's investigation of the conditions in the Carousel neighborhood:

- Based on the testing data, the Los Angeles County Health Department and the Regional Board have all concluded that there is no exposure in the neighborhood that poses an imminent health risk or explosion hazard.
- Results from sampling of indoor and outdoor air and sub-slab soil vapor have shown that vapor intrusion from sub-slab soil vapor to indoor air is not occurring to any measurable extent in homes.
- Groundwater monitoring has revealed the presence of groundwater impacts beneath the site that are generally limited to the shallow zone. The groundwater plume is stable and/or decreasing and has not migrated offsite to any significant extent. The drinking water in the Carousel neighborhood, which does not come from groundwater in the shallow zone, is safe. California Water Service Company regularly tests community drinking water, and has confirmed that the water meets the applicable drinking water quality standards.
- Soil impacts exist at many of the properties in the Carousel neighborhood. These impacts do not pose an imminent health risk. Using very conservative, health-protective standards, the remedial approach proposed in the Remedial Action Plan fully addresses the potential for exposure to impacted shallow soils at residential properties.

In light of these findings and based on the data and the applicable scientific guidance and protocols, the Revised **Remedial Action Plan** proposes the following steps:

- Excavation of shallow soils from the yards at residential properties will be conducted at properties where Remedial Action Objectives based on unrestricted land use are not met under existing conditions. Excavation will be conducted in both landscaped and hardscaped areas of residential yards, excluding beneath City sidewalks and streets, to a depth of 5 feet below ground surface ("bgs"). The excavation will also remove residual concrete slabs if encountered within the depth excavated.
- Because residents cannot excavate below 3 feet without obtaining a permit, the possibility of exposure to soils remaining below 3 feet bgs is currently controlled by existing ordinances. The proposed excavation to 5 feet bgs is to satisfy the Board's concerns about residents excavating below 3 feet without getting a permit. The Revised Remedial Action Plan explains how notifications, management, and handling of residual soils that are impacted by COCs will limit exposures to deeper soils.
- In order to address the Board's desire to remove a greater amount of mass more quickly to minimize potential impacts to groundwater, Shell also proposes targeted deeper excavation of soils from 5 to 10 feet bgs at specific properties where data analysis and modeling indicate that concentrations exceed 10 times the site-specific cleanup goals ("SSCGs") for total petroleum hydrocarbons. Soil vapor extraction ("SVE") and

bioventing will be used to address petroleum hydrocarbons and VOCs in residual soils and soil vapor, and methane in soil vapor. SVE wells will be installed in City streets and on certain residential properties, as appropriate to ensure adequate coverage.

- Bioventing will be conducted via cyclical operation of SVE wells to increase oxygen levels in subsurface soils and promote microbial activity and degradation of longer-chain petroleum hydrocarbons.
- Extensive testing at the site shows that vapor intrusion does not appear to be impacting indoor air. However, as an additional protective measure, sub-slab mitigation will be implemented at 28 properties based on sub-slab soil vapor data. In addition, Shell is prepared to offer installation of a sub-slab mitigation system to any of the homeowners in the Carousel neighborhood to alleviate concerns about potential impacts to their indoor air from the site.
- LNAPL will continue to be recovered where it has accumulated in monitoring wells to the extent technologically and economically feasible, and where a significant reduction in current and future risk to groundwater will result.
- Compounds in groundwater will be reduced to the extent technologically and economically feasible via source reduction and monitored natural attenuation. Groundwater monitoring will continue as part of remedial actions. Monitored natural attenuation could be paired with contingency groundwater remediation of oxidant injection in areas where Site-related COCs exceed 100x MCL if, after a five-year review following start of SVE/bioventing operations, the groundwater plume is not stable or decreasing. In addition, upgradient sources would need to be addressed by the overseeing agencies.

Shell believes that this approach accomplishes the remedial objectives set forth in the Revised Site-Specific Cleanup Goals Report, protects the health and safety of the Carousel residents, minimizes the inconvenience to the residents and surrounding communities, sets in place a long-term groundwater protection plan, achieves the SSCGs, and, importantly, preserves the integrity of the neighborhood.

Along with the Revised Remedial Action Plan, Shell is submitting a Revised Feasibility Study and a Revised HHRA Report. The Revised **Feasibility Study** analyzes and compares in detail the selected approach along with a number of possible alternative approaches, and weighs each alternative against the goals of reducing potential exposures to residents, protecting groundwater quality, preserving the neighborhood and the other factors set forth in the Cleanup and Abatement Order for the Carousel neighborhood, State Water Board Resolution No. 92-49, and other applicable regulations.

The Revised **HHRA Report** applies the Site-Specific Cleanup Goals to the extensive testing data that Shell has obtained from the Carousel residences, and the results of this analysis was used to determine what specific work needs to be done at each of the Carousel residences.

The next step is for the Regional Board and the other involved agencies to review the Revised Remedial Action Plan. It will then be made available for public comment and a simultaneous public comment period will occur as part of the environmental review required by the California Environmental Quality Act that the Regional Board has undertaken with Shell's support. Once a Final Environmental Impact Report is issued and adopted, the Revised Remedial Action Plan receives final approval from the Regional Board, the necessary permits for the work have been issued and access is granted, the remedial work in the Carousel neighborhood will begin. Shell plans to meet with the homeowners and residents at individual properties (and their legal representatives) where work will be performed to explain the property specific remedial plan, answer questions, gather information that will be used in arranging alternative accommodations during the work, and schedule the work.

Shell looks forward to continuing to work with the Regional Board and is committed to moving forward with implementing this Revised Remedial Action Plan as soon as possible.

Sincerely,

Douglas Weimer
Sr. Principle Program Manager
Shell Oil Products US

Enclosures

Prepared for:

Shell Oil Products US
20945 S. Wilmington Avenue
Carson, CA 90810

Revised Feasibility Study Report

Former Kast Property
Carson, California

Prepared by:

Geosyntec consultants

engineers | scientists | innovators

2100 Main Street, Suite 150
Huntington Beach, CA 92648
Telephone: (714) 465-1238
Fax (714) 969-0800
www.geosyntec.com

Project Number: SB0484-03-03

June 30, 2014

REVISED FEASIBILITY STUDY REPORT

Former Kast Property
Carson, California

Prepared for:
Shell Oil Products US
Prepared by:
Geosyntec Consultants, Inc.

CERTIFICATION

Mark Grivetti, P.G., CHG
Principal Hydrogeologist

Mark Schultheis, P.E.
Principal

Geosyntec
consultants

REVISED FEASIBILITY STUDY REPORT
FORMER KAST PROPERTY
CARSON, CALIFORNIA

I am the Project Manager for Equilon Enterprises LLC doing business as Shell Oil Products US for this project. I am informed and believe that the matters stated in the Revised Feasibility Study Report dated June 30, 2014 are true, and on that ground I declare, under penalty of perjury in accordance with Water Code section 13267, that the statements contained therein are true and correct.

Doug Weimer

____
Doug Weimer
Principal Project Manager
Shell Oil Products US
June 30, 2014

Geosyntec consultants

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
AS	Air Sparging
bgs	Below ground surface
BHC	Barclay Hollander Corporation
BTEX	Benzene, toluene, ethylbenzene, xylene
Cal/OSHA	State of California – Division of Occupational Safety and Health
Cal-Water	California Water Services Company
CAO	Cleanup and Abatement Order
City	City of Carson
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CLSM	Controlled Low Strength Material
cm	Centimeters
CO_2	Carbon dioxide
COCs	Constituents of Concern
CWC	California Water Code
cy	Cubic yard
dB	Decibel
Dole	Dole Food Company, Inc.
DTSC	Department of Toxic Substances Control
ECs	Engineering Controls
EHS	Environmental, Health and Safety
FEMA	Federal Emergency Management Agency
FS	Feasibility Study
ft	Foot or feet
g	Grams
GAC	Granular activated carbon
Geosyntec	Geosyntec Consultants, Inc.
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HSAA	Hazardous Substances Account Act
HSC	Health and Safety Code
HSP	Health and Safety Plan
ILCR	Incremental Lifetime Cancer Risk
IRAP	Interim Remedial Action Plan
ISCO	In-situ chemical oxidation
ITRC	Interstate Technology & Regulatory Council

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

L	Liter
LA	Los Angeles
LACDPW	Los Angeles County Department of Public Works
lb	Pound
LNAPL	Light Non-Aqueous Phase Liquid
m	Meter
MAROS	Monitoring and Remediation Optimization System
MCL	Maximum Contaminant Level
mg/kg	Milligrams per kilogram
MNA	Monitored natural attenuation
msl	Mean sea level
NAPL	Non-aqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NL	Notification level
O&M	Operation and maintenance
ORC®	Oxygen Release Compound
OSHA	Occupational Safety and Health Administration
PAHs	Polycyclic aromatic hydrocarbons
PCE	Tetrachloroethene
PPE	Personnel protection equipment
ppm	Parts per million
PSI	Pounds per square inch
PSIG	Pound-force per square inch gauge
PVC	Polyvinyl chloride
RAOs	Remedial action objectives
RAP	Remedial Action Plan
Regional Board	Los Angeles Regional Water Quality Control Board
Residential Hardscape	Walkways, driveways, patios, hardscape associated with landscaping
RI	Risk Index
RI/FS	Remedial Investigation and Feasibility Study
ROI	Radius of influence
ROVI	Radius of vacuum influence
RWQCB	Los Angeles Regional Water Quality Control Board
SCAQMD	South Coast Air Quality Management District
scfm	Standard cubic feet per minute
SCM	Site Conceptual Model
Shell	Shell Oil Products United States
Site	Former Kast Property, Carson, California
SOPUS	Shell Oil Products United States
SP	Sodium persulfate

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

SSD	Sub-slab depressurization
SVE	Soil vapor extraction
SVOCs	Semi-volatile organic compounds
TCE	Trichloroethene
TPH	Total petroleum hydrocarbons
URS	URS Corporation
USEPA	United States Environmental Protection Agency
VOCs	Volatile organic compounds
VI	Vapor Intrusion
Work Plan	Pilot Test Work Plan
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
µg/m^3	Micrograms per cubic meter
%	Percent

EXECUTIVE SUMMARY

Geosyntec Consultants, Inc. (Geosyntec), with support from URS Corporation (URS), prepared this Revised Feasibility Study Report (Revised FS Report) for the former Kast Property (Site) in Carson, California on behalf of Equilon Enterprises LLC, doing business as Shell Oil Products US (Shell or SOPUS). This Revised FS Report is being submitted concurrently with two related and separate documents for the Site: the Revised Human Health Risk Assessment (Revised HHRA) [Geosyntec, 2014c] and Revised Remedial Action Plan (Revised RAP) [URS and Geosyntec, 2014b].

Shell submitted a Revised Site-Specific Cleanup Goal Report (Revised SSCG Report) on October 21, 2013 [Geosyntec, 2013b] in response to a RWQCB directive dated August 21, 2013. In the Revised SSCG Report, Shell conducted a Screening FS which included a general evaluation of various alternatives for remediation of the Site. In a letter from RWQCB dated January 23, 2014, RWQCB provided comments and directives to Shell [LARWQCB, 2014]. The comments directed Shell to prepare a RAP containing remedial alternatives, and that would be consistent with the following directive:

> "Consistent with State Water Board Resolution 92-49, the RAP shall evaluate the alternatives with respect to effectiveness, feasibility, and cost and propose a remedy or remedies that have a substantial likelihood to achieve compliance, within a reasonable time frame, with the cleanup goals and objectives."

This Revised FS Report, submitted concurrently with the Revised RAP, fulfills this requirement with respect to evaluation of alternatives for remediation of the former Kast Property. This Revised FS Report also meets the requirements set forth in CAO No. R4-2011-0046 issued to Shell by RWQCB on March 11, 2011. This Revised FS Report replaces and updates the Screening FS included in the Revised SSCG Report and the previously submitted FS Report dated March 10, 2014, and contains a detailed evaluation of remedial alternatives as requested by RWQCB [LARWQCB, 2014]. This Revised FS Report follows the general form set forth in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (RI/FS Guidance) [USEPA, 1988].

The Revised FS Report addresses remediation for constituents of concern (COCs) found to be present at the Site. Based on the results of the Revised HHRA, the primary Site COCs include the petroleum hydrocarbons TPH-diesel (TPHd) and TPH-motor oil (TPHmo), and VOCs such as benzene, ethylbenzene, and naphthalene related to petroleum hydrocarbon impacts (**Table 2-1**).

In the Revised HHRA, remedial action objectives (RAOs), which are specific to a medium (i.e., soil, soil vapor, or groundwater), and which contain numerical target risk levels for Site COCs, are developed. RAOs also consider identified receptors at the Site and regulatory requirements. The following RAOs are proposed for the Site based on the above Site-specific considerations:

- Prevent human exposures to concentrations of COCs in soil, soil vapor, and indoor air such that total (i.e., cumulative) lifetime incremental carcinogenic risks are within the NCP risk range of 1×10^{-6} to 1×10^{-4} and noncancer Hazard Indices are less than 1 or concentrations are below background, whichever is higher. Potential human exposures include onsite residents and construction and utility maintenance workers. For onsite residents, the lower end of the NCP risk range (i.e., 1×10^{-6}) and a noncancer hazard index less than 1 have been used.
- Prevent fire/explosion risks in indoor air and/or enclosed spaces (e.g., utility vaults) due to the accumulation of methane generated from the anaerobic biodegradation of petroleum hydrocarbons in soils. Eliminate methane in the subsurface to the extent technologically and economically feasible.
- Remove or treat mobile LNAPL to the extent technologically and economically feasible, and where a significant reduction in risk to groundwater will result.
- Reduce COCs in groundwater to the extent technologically and economically feasible to achieve, at a minimum, the water quality objectives in the Basin Plan to protect the designated beneficial uses, including municipal supply.

A further consideration is to maintain residential land use of the Site and avoid displacing residents from their homes or physically dividing the established Carousel community.

Following development of RAOs, the Revised FS Report includes identification and screening of a range of technologies, each of which can address a specific Site issue and contribute to meeting a RAO. Screening of technologies is followed in the Revised FS Report by the identification, screening and detailed evaluation of a range of remedial alternatives for the Site.

Technologies in the Revised FS Report are identified in two categories: (1) technologies that interrupt the human health exposure pathway; and (2) technologies that remove COC mass in addition to interrupting the human health exposure pathway. In the first category, the following technologies are identified:

- Potential sub-slab vapor intrusion mitigation, which may include the installation of passive barriers, passive venting, or active sub-slab depressurization.
- Capping portions of the Site, which involves the placement of cover material over impacted media.
- Institutional controls, which restrict access to impacted media.

Technologies which remove COC mass in addition to interrupting the human health exposure pathway include the following:

- Excavation
- Soil vapor extraction (SVE)
- Bioventing
- In-situ chemical oxidation (ISCO)
- Mobile light non-aqueous phase liquid (LNAPL) source removal
- Contingency remediation of groundwater (if needed), including::
  - Air sparging with SVE
  - Biosparging
  - Oxidant injection
- Groundwater monitored natural attenuation (MNA)
- Three methods that may assist in mass removal, but do not themselves remove COCs:
  - Lifting and cribbing houses to allow excavation beneath houses
  - Temporarily moving houses to allow excavation beneath houses
  - Removal of residual concrete reservoir slabs.

After screening (**Table 4-1**), five technologies are eliminated from further consideration: in-situ chemical oxidation in soils, lifting and cribbing houses to allow excavation beneath houses, temporarily moving houses to allow excavation beneath houses, air sparging with SVE, and biosparging with SVE.

Groups of remaining technologies are combined into preliminary remedial alternatives to develop complete cleanup approaches. The following preliminary remedial alternatives are developed:

- Alternative 1 – No Action.
- Alternative 2 – Entire Site Excavation of Impacted Soils.
- Alternative 3 – Entire Site Excavation to 10 Feet.

- Alternative 4 – Excavation of Site soils from both landscaped areas and beneath residential hardscape; existing institutional controls; SVE/bioventing; sub-slab vapor intrusion mitigation; mobile LNAPL removal; groundwater MNA; contingency groundwater remediation; and long-term monitoring. Four separate excavation alternatives in this category are evaluated in the Revised FS Report:
    - Alternative 4B – Excavation to 3 feet bgs
    - Alternative 4C – Excavation to 5 feet bgs
    - Alternative 4D – Excavation to 5 feet bgs, plus targeted deeper excavation to 10 feet bgs for additional mass removal
    - Alternative 4E – Excavation to 10 feet bgs.
- Alternative 5 – Excavation of Site soils from landscaped areas only; existing institutional controls; SVE/bioventing; sub-slab vapor intrusion mitigation; mobile LNAPL removal; groundwater MNA; contingency groundwater remediation, and long-term monitoring. Four separate excavation alternatives in this category are evaluated:
    - Alternative 5B – Excavation to 3 feet bgs
    - Alternative 5C – Excavation to 5 feet bgs
    - Alternative 5D – Excavation to 5 feet bgs, plus targeted deeper excavation to 10 feet bgs for additional mass removal
    - Alternative 5E – Excavation to 10 feet bgs.
- Alternative 6 – Cap Site.
- Alternative 7 – Capping the landscaped areas of the Site; existing institutional controls; SVE/bioventing; sub-slab vapor intrusion mitigation; mobile LNAPL removal; groundwater MNA; and contingency groundwater remediation.

The preliminary remedial alternatives are screened to assess those which represent realistic approaches to Site cleanup (**Table 5-3**). In this screening step, three alternatives are eliminated: Alternatives 2, 3, and 6.

Remedial alternatives which are retained after screening (**Table 5-4**), and the specific technologies employed as part of those alternatives, then are evaluated against the following criteria (**Table 7-1**):

- Overall protection of human health and the environment;
- Compliance with applicable or relevant and appropriate requirements (ARARs);
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, and volume through treatment;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance;
- Consistency with State Water Resources Control Board Resolution 92-49;
- Social considerations; and
- Sustainability.

An additional criterion, Community Acceptance, will be considered following public comment on the Revised FS Report and on the Revised RAP.

After the evaluation of alternatives is complete, the alternatives are compared against each other. This comparison, summarized below, leads to a recommended remedial alternative.

Alternative 1 does not provide treatment of the COCs, and therefore does not meet the requirement of overall protection of human health and the environment nor does it comply with ARARs.

Alternative 7 would have a very high social impact. A cap over all Site landscaped areas would likely decrease the aesthetic appeal of the community. All planting would need to be done above ground (such as in planters). This likely would have a more long-term effect on the community than any of the alternatives involving excavation.

Alternatives 5B – 5E are found to be non-protective of residents who could potentially be exposed to impacted soils during post-remediation excavation of residential hardscape on their properties. Since they would pose a continuing nuisance, Alternatives 5B – 5E do not meet the requirements of Resolution 92-49 and are therefore not considered for implementation.

Alternatives 4B – 4E remain as the alternatives considered for implementation. The key difference among Alternatives 4B – 4E is the depth of excavation, which affects many of the evaluation criteria. The comparative evaluation of Alternatives 4B – 4E, therefore, is a balancing of the benefits of deeper excavation versus the adverse effects and complications related to deeper excavation. Alternative 4B presents an excavation to 3 ft bgs, which would be protective of health and would provide significant mass removal. Because Alternative 4B would excavate impacted soils to a depth of 3 feet, Shell believes the City of Carson Building Code is an institutional control which provides a regulatory basis for the protection of residents from contact with impacted soils, and therefore resolves the issue of nuisance.

Excavation to 5 feet bgs (Alternative 4C) or to 5 feet bgs with targeted deeper excavation to 10 feet bgs (Alternative 4D) would remove more mass and slightly reduce the potential for nuisance associated with inadvertent contact with impacted soils. Excavation to 5 or 10 feet bgs would, however, have drawbacks. Although excavation to these depths would remove more TPH mass and further minimize the potential for inadvertent resident contact with impacted soils, deeper excavation comes at substantially increased cost. The amount of mass that would be removed represents a relatively small proportion of the total mass present at the Site. Removal of additional mass, especially below 5 feet does not significantly further reduce potential risk to residents. Additionally, deeper excavation to 5 feet bgs or 10 feet bgs would require more time to implement, longer relocation times, and result in more days when impacted soil would be exposed, and therefore a greater potential for exposure to the community and workers for a longer period than excavating to 3 feet bgs. This deeper excavation would be a much more complicated excavation, it would result in significant additional disruption of the residential community, and it would result in a negligible change in the time required to meet groundwater SSCGs.

Excavation of the entire Site to 10 feet bgs (Alternative 4E) would remove more mass than the other alternatives, but would not reduce nuisance nor result in a significant decrease in the time required to meet groundwater SSCGs. Such deeper excavation also would require 4.8 years longer than excavation to 3 feet bgs (Alternative 4B), 3.8 years longer than excavation to 5 feet (Alternative 4C), and 2.7 years longer than excavation to 5 feet plus targeted deeper excavation to 10 feet (Alternative 4D). Excavation to 10 feet also would be associated with an economically infeasible cost. The incremental mass reduction associated with the incremental cost of deeper excavation is described in Section 6.2.2.1 and shown in **Table 6-1**. This information shows that the excavation associated with Alternative 4E can be achieved only at an incremental cost per pound of $136 compared with Alterantive 4D. This analysis supports Alternative 4D over 4E.

When compared with the evaluation of other alternatives, Alternative 4B meets the threshold criteria and provides the best balance of all alternatives against each other evaluation criteria (see Section 7 and Section 8). Commonly in FS reports, the criterion of State Acceptance is evaluated following comment on the FS report and on the RAP. However, for the former Kast Property there is ample public record to allow an informed evaluation of RWQCB's position to be stated and evaluated in this Revised FS Report. In its comments on the March 10, 2014 FS Report and RAP, RWQCB stated that it has concerns with Alternative 4B, primarily based on RWQCB's following issues regarding an excavation to 3 feet bgs:

- An excavation to 3 ft bgs may not be sufficient to address nuisance caused by the waste at the Site.
- Alternative 4B may not protect residents from exposure during the some types of residential activities such as gardening or small project excavations.
- Alternative 4B would leave a considerable mass of waste in Site soil that could continue to leach to groundwater.
- Alternative 4B does not meet the requirements of Resolution 92-49.

Based on RWQCB's expressed concerns, Shell believes that excavation to 5 feet bgs would be more acceptable to RWQCB than excavation to 3 feet bgs. RWQCB also asked Shell to explore the feasibility of technologies to excavate to 10 feet where practicable in some cases. Shell has done so, and has included an assessment of incremental mass removal against the incremental cost of achieving this incremental mass removal (See **Table 6-1**). It is anticipated that Alternative 4C would likely be more acceptable to RWQCB than Alternative 4B for the following reasons:

- An excavation to 5 ft bgs would be sufficient to address RWQCB's concern of a potential nuisance caused by the waste at the Site (although Shell does not concede that such a nuisance exists).
- Alternative 4C would protect residents from exposure during residential activities that may reach soils deeper than 3 feet bgs such as gardening or small project excavations.
- Alternative 4C would remove a larger mass of waste in Site soil than would be removed under Alternative 4B.
- It is logical to assume that the larger amount of mass removal under Alternative 4C would result, in some incremental (although not measureable) reduction of operating time of the SVE/bioventing system, and therefore the time required to achieve groundwater cleanup goals, when compared with Alternative 4B.

It is further anticipated that Alternative 4D would likely be more acceptable to RWQCB than Alternatives 4B or 4C for the following reasons:

- An excavation to 5 ft bgs with targeted excavation to 10 ft bgs would address RWQCB's concern regarding a potential nuisance by providing less potential for residents to contact impacted soils during gardening or small project excavations than a 3-foot excavation, although Shell does not concede that such a nuisance exists with a 3-foot excavation.
- Alternative 4D would protect residents from exposure during residential activities that may reach soils deeper than 3 feet bgs such as gardening or small project excavations (although this is exceptionally unlikely to occur below 5 feet).
- Alternative 4D would remove a larger mass of waste in Site soil than would be removed under Alternatives 4B or 4C.
- It is logical to assume that this even larger amount of mass removal under Alternative 4D would result, in some incremental (although not measureable) reduction of operating time of the SVE/bioventing system, and therefore the time required to achieve groundwater cleanup goals, when compared with Alternatives 4B or 4C.

Shell has carefully considered RWQCB comments and recommends selection of Alternative 4D, excavation to 5 feet bgs plus targeted deeper excavation to 10 feet bgs, as the recommended remedial alternative for development in the Revised RAP.

1. INTRODUCTION

1.1 Regulatory Basis

Geosyntec Consultants, Inc. (Geosyntec), with support from URS Corporation (URS), prepared this Revised Feasibility Study Report (Revised FS Report) for the former Kast Property (Site) in Carson, California on behalf of Equilon Enterprises LLC, doing business as Shell Oil Products US (Shell or SOPUS).

This Revised FS Report, and companion Revised Human Health Risk Assessment (Revised HHRA) [Geosyntec, 2014c] and Revised Remedial Action Plan (RAP) [URS and Geosyntec, 2014b], are being submitted concurrently as separate documents. Preparation of these documents follows a series of environmental investigations performed by URS and Geosyntec on Shell's behalf in response to Section 13267 letters issued to SOPUS by the Los Angeles Regional Water Quality Control Board (RWQCB or Regional Board) on May 8 and October 1, 2008 and November 18, 2009, Section 13304 letter dated October 15, 2009, and Cleanup and Abatement Order (CAO) R4-2011-0046 dated March 11, 2011.

Shell submitted a Revised Site-Specific Cleanup Goal Report (Revised SSCG Report) on October 21, 2013 [Geosyntec, 2013b] in response to a RWQCB directive in a letter of August 21, 2013. In the Revised SSCG Report, Shell conducted a Screening FS which included a general evaluation of various alternatives for remediation of the Site. In a letter from RWQCB dated January 23, 2014, RWQCB provided comments and directives to Shell [LARWQCB, 2014a]. The comments directed Shell to prepare a RAP including:

> "Consistent with State Water Board Resolution 92-49, the RAP shall evaluate the alternatives with respect to effectiveness, feasibility, and cost and propose a remedy or remedies that have a substantial likelihood to achieve compliance, within a reasonable time frame, with the cleanup goals and objectives."

In response, Shell submitted a HHRA [Geosyntec, 2014a], a FS Report [Geosyntec 2014b], and a RAP [URS and Geosyntec, 2014b] on March 10, 2014. On April 30, 2014, RWQCB responded to these submittals with a comment letter [RWQCB, 2014c], and a Notice of Violation (NOV) for a deficient RAP [RWQCB, 2014d]. In addition, as attachments to the RWQCB comment letter, and with a directive to Shell to address the attached comments, the Office of Environmental Health Hazard Assessment responded with a comment memorandum on the HHRA [OEHHA, 2014]; the UCLA Expert Panel responded with a comment memorandum on the submittals [UCLA Expert Panel, 2014b]; and prepared an additional memorandum providing TPH mass calculations

[RWQCB, 2014e]. Together, these response documents required that Shell resubmit the FS Report, the RAP and the HHRA. Shell responded to the NOV by letter dated May 12, 2014 and has met with RWQCB on multiple occasions to discuss the comments and resolve the issues raised in the NOV. Shell is complying with RWQCB's request with this Revised FS Report, which is being submitted concurrently with the Revised RAP [URS and Geosyntec, 2014b] and the Revised HHRA [Geosyntec, 2014c].

This Revised FS Report replaces and updates the Screening FS included in the Revised SSCG Report and the FS Report submitted on March 10, 2014. This Revised FS Report is not required by RWQCB to be a CERCLA-compliant FS Report, but it follows the general form of the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (RI/FS Guidance) [USEPA, 1988].

RWQCB directed Shell to use RWQCB-revised SSCGs in preparing the Revised RAP and Revised HHRA [LARWQCB, 2014a] and provided corrections for the SSCGs for total petroleum hydrocarbons as motor oil (TPHmo) and benzene in subsequent correspondence [LARWQCB, 2014f]. RWQCB-directed SSCGs are presented in the Revised HHRA and discussed in Section 3.2 of this Revised FS Report. The SSCGs shown in Section 3 tables support unrestricted residential land use for the Site.

Additionally, RWQCB directed Shell to address recommendations from the UCLA Expert Panel. In its development and structure, this Revised FS Report considers comments from the UCLA Expert Panel cautioning against eliminating remediation options prior to preparation of the Revised RAP [UCLA Expert Panel, 2013]. The specific example provided by the UCLA Expert Panel to support this comment was that the Revised SSCG Report eliminated bioventing. Bioventing was in fact included in the FS Report, and also is included in this Revised FS Report. Bioventing is incorporated into most of the remedial alternatives. In addition to the inclusion of bioventing, in response to the UCLA Expert Panel's comments, this Revised FS Report provides a broader assessment of applicable technologies, specifically use of auger excavation methods (see Section 5), than was included in Screening FS included in the Revised SSCG Report and the FS Report.

1.2 Revised Feasibility Study Report Objectives

The objective of this Revised FS Report is to identify and screen remedial technologies capable of contributing to the Site cleanup, then to identify, screen and evaluate remedial alternatives capable of achieving the RAOs presented in the Revised HHRA, leading to the recommendation of a remedial alternative for further development in the Revised RAP.

1.3 Revised Feasibility Study Organization

The remainder of this Revised FS Report is organized as follows:

- **Section 2** provides Site background information;
- **Section 3** contains a brief summary of the remedial action objectives (RAOs), target risk levels, and identifies the resultant properties which require remediation;
- **Section 4** presents the identification and screening of technologies that may be used to remediate the former Kast Property;
- **Section 5** assembles the retained technologies into remedial alternatives, then screens these alternatives;
- **Section 6** presents the detailed evaluation of the retained remedial alternatives;
- **Section 7** provides a comparison of remedial alternatives to provide the basis for selection of a recommended alternative; and
- **Section 8** summarizes the recommended alternative for further development in the RAP.

2. SITE BACKGROUND INFORMATION

2.1 Site History

The former Kast Property is a former petroleum storage facility that was operated by Shell Company of California and then Shell Oil Company from the mid-1920s to the mid-1960s. The property was sold to residential real estate developers who redeveloped it as the Carousel Community residential housing tract in the late 1960s. The Site is located in the City of Carson in the area inclusive of Marbella Avenue on the west side, Panama Avenue on the east side, E. 244th Street on the north side, and E. 249th Street on the south side (**Figure 2-1**). The Site is bordered by the Los Angeles County Metropolitan Transportation Authority (MTA) railroad tracks to the north (formerly owned by the BNSF Railway Company), Lomita Boulevard to the south, residential properties of the Monterey Pines Community and industrial property of the former Turco Products Facility to the west, and residential properties to the east (**Figure 2-2**).

Detailed Site background information, including information on historical Site operations, onsite structures formerly present, and Site demolition and development by the developers was provided in the Plume Delineation Report [URS, 2010a] and the Site Conceptual Model [Geosyntec, 2010], included as Appendix A to the Plume Delineation Report. The Site was undeveloped until 1923 when Shell Company of California purchased the 44-acre property from Mary Kast and constructed three oil storage reservoirs on the Site. Two of the reservoirs (the central and southern Reservoirs No. 5 and 6) had capacities of 750,000 barrels, and the third (northern Reservoir No. 7) had a capacity of 2 million barrels. The reservoirs were partially in-ground and partially aboveground and with earthen berms constructed using soils excavated from the below-ground portions of the reservoirs. The reservoirs had wire-mesh reinforced concrete-lined floors and side walls, and were covered with wood frame roofs supported by wooden posts on concrete pedestals [URS, 2010a]. The outer berms were 15 to 20 feet above surrounding grade, and the outer walls of the berms are believed to have been covered with asphalt. The oil storage reservoirs were primarily used to store crude oil. Historical records cited in the Plume Delineation Report [URS, 2010a] indicate that bunker oil or heavier intermediate refinery streams may also have been stored in the reservoirs at one time, but the time and quantity of bunker oil storage is unknown. The reservoirs were not used to store refined finished hydrocarbon products.

Site use remained as an active oil storage facility until approximately the late 1950s, when the Site became used on a standby reserve basis. In October of 1965, Shell Oil Company entered into a Purchase Option Agreement to sell the Site, with the oil storage reservoirs intact, to Richard Barclay or his nominee. Richard Barclay was a principal in

Barclay Hollander Curci, Inc., later renamed Barclay Hollander Corporation (BHC), and Lomita Development Company (Lomita Development). Lomita Development was subsequently merged into Barclay Hollander Curci. BHC is now a wholly-owned subsidiary of Dole Food Company, Inc. (Dole).

In December 1965, Richard Barclay designated Lomita Development as his nominee for purchase of the Site. The property was evaluated for BHC and Lomita Development by Pacific Soils Engineering, a BHC-owned company, which performed soil borings and developed engineering studies and grading plans for the Site. Beginning in 1966, BHC and its contractors conducted these studies, removed the remaining residual oil and water from the reservoirs, demolished the reservoirs and graded the Site. Lomita Development's request to rezone the Site from industrial to residential was approved by Los Angeles County in October 1966, and in the same month, title was transferred to Lomita Development under the Purchase Option Agreement. Construction of homes began in 1967 and was apparently completed in or around the early 1970s. The Site has remained residential since that time. More detailed information on the Site background is included in the Plume Delineation Report [URS, 2010a], in Appendix A [Geosyntec, 2010].

2.2 Regulatory Involvement

The Site came to the attention of RWQCB in 2008 when environmental investigations for the neighboring former Turco Products Facility, located directly west of the Site, discovered contamination by petroleum hydrocarbons at sample locations within the former Kast Property. The Department of Toxic Substances Control (DTSC) communicated these findings to RWQCB in March 2008, and in April 2008 RWQCB sent an inquiry to Shell regarding the status of any environmental investigations at the Site. This inquiry was followed by RWQCB's California Water Code (CWC) Section 13267 Order to Conduct an Environmental Investigation at the former Kast Property issued to Shell on May 8, 2008. Shell has conducted a series of investigations, pilot studies, and other environmental evaluations of the Site in response to that Order and subsequent 13267 Orders issued on October 1, 2008 and November 18, 2009, Section 13304 Order dated October 15, 2009, and Cleanup and Abatement Order (CAO) R4-2011-0046 dated March 11, 2011, as amended.

RWQCB's letter dated January 23, 2014 required that the RAP and supporting documents should address the comments by the Expert Panel, included as an attachment to that letter. The FS Report was submitted, and this Revised FS Report is being submitted, in response to RWQCB's recommendation that a separate FS Report be prepared for this project [LARWQCB, 2014a]. This Revised FS Report follows the general form of the *Guidance for Conducting Remedial Investigations and Feasibility*

Studies Under CERCLA (RI/FS Guidance) [USEPA, 1988]. The alternative recommended in this Revised FS Report is further developed in the Revised RAP.

2.3 Site Setting, Geology and Hydrogeology

The Site consists of approximately 44 acres occupied by 285 single-family residential properties and City streets collectively referred to as the Carousel Tract. It is located within the West Coast Basin of the Los Angeles Coastal Plain, approximately 3 miles northwest of Long Beach Harbor. The Site is relatively flat, with a gradual slope to the northwest. The elevation across the Site ranges from approximately 30 to 40 feet above mean sea level (msl). The Site is not located within a 100- or a 500-year Federal Emergency Management Agency (FEMA) designated flood zone [URS, 2008]. Historically, the Site area has been an oil production area, and active oil production wells are still present to the west and northwest of the Site. Due to historical oil production, the area directly south of the Site across Lomita Boulevard is designated as within the City of Los Angeles methane mitigation zone.

Geologically, the Basin consists of a very thick sequence of unconsolidated marine and continental sediments overlying consolidated sedimentary rocks that range in age from a few thousand years to tens of million years. Based on Site investigations, the upper 10 feet of soil beneath the Site generally is dominantly fine grained and consists of silt with layers or lenses of silty fine sand. Soils between 10 and 15 feet bgs consist primarily of silt and silty fine sand. From 15 to 85 feet bgs Site soils consist of fine sands to silty fine sand. Soils encountered between 85 and approximately 180 feet bgs consist of silt, silty sand, and fine to medium sand.

Shallowest groundwater encountered beneath the Site occurs within the Bellflower aquitard, an overall fine-grained unit that locally has sandy intervals. First groundwater occurs at a depth of approximately 53 feet beneath the Site, with a groundwater flow direction to the northeast [URS, 2014].

The Gage aquifer occurs beneath the Bellflower aquitard and extends from approximately 90 to 170 feet bgs. Groundwater flow direction in the Gage aquifer is to the east-northeast. The Lynwood aquifer, also known as the “400-foot Gravel,” and the deeper Silverado aquifer are located below the Gage aquifer and may be merged in the Site vicinity [DWR, 1961]. The Lynwood aquifer is dominated by coarse sand and gravel in the Site vicinity [Equilon, 2001]. These two aquifers extend from approximately 200 feet bgs to at least 550 feet bgs in the Site vicinity. The Lynwood and Silverado aquifers are major sources of groundwater for municipal drinking water wells in the Los Angeles Basin [Equilon, 2001]. However, neither the Gage aquifer, nor the shallow Bellflower aquitard (in which the first regional unconfined groundwater was encountered at the Site) is a known source for drinking water in the Site area.

The nearest drinking water well, CWS Well 275, is located 435 feet west of the western Site boundary, upgradient of the Site and downgradient of the Former Fletcher Oil Refinery (**Figure 2-2**). CWS Well 275 produces water from the Lynwood and Silverado aquifers which are below 200 feet bgs in this area. Drinking water is supplied to the Carousel neighborhood and surrounding communities by California Water Services Company (Cal-Water), which regularly tests the drinking water to ensure that it meets state and federal drinking water standards. Information on the quality of water provided by Cal-Water is available from https://www.calwater.com/docs/ccr/2012/rd-dom-2012.pdf.

A significant body of additional background information for the Site is contained in the Revised RAP [URS and Geosyntec, 2014b].

2.4 Constituents of Concern

An initial step in the HHRA process is an evaluation of data to identify medium-specific COCs [Geosyntec, 2014b]. Chemicals that were detected in at least one sample in a given medium were included in the COC selection process; however, due to the large number of soil samples collected (over 10,000), if a chemical had a frequency of detection less than 0.05 percent, it was not evaluated further in the Revised HHRA as a COC. A toxicity-concentration screen using conservative risk-based screening levels was then used to focus the list of COCs to those chemicals that have the potential to contribute significantly to potential risk at the Site [Geosyntec, 2013b]. In addition, the COC screening process for metals and carcinogenic PAHs (cPAHs as benzo(a)pyrene equivalents) included a comparison to background concentrations, with only those compounds exceeding background and the conservative risk-based screening level being selected as COCs for evaluation in the HHRA.

The COCs that have been identified for soil, sub-slab soil vapor, and soil vapor and that were carried forward into the HHRA are summarized in **Table 2-1**.

As discussed in the Revised SSCG Report [Geosyntec, 2013b], some COCs may have migrated through the vadose zone to groundwater. However, based on groundwater data collected at and adjacent to the Site, it appears that the extent of the Site-related COCs in groundwater are stable and decreasing. Furthermore, COC values in the downgradient wells near the Site boundary are below or close to maximum contaminant levels (MCLs) and Notification Levels (NLs), as applicable. Based on these facts and the age of the releases of COCs in the vadose zone (>~50 years), it is unlikely that significant additional groundwater impacts would result from the remaining soil impacts. However, COCs currently present in the vadose zone at the Site, which are also present in Site groundwater, may theoretically represent a continuing source of potential groundwater contamination. To address this potential, soil COCs for the leaching to groundwater pathway were selected based on whether the constituent was detected in groundwater above its respective MCL or NL. **Table 2-1** also includes the COCS that were identified for evaluation of potential leaching to groundwater in the HHRA.

Based on the results of the HHRA, primary COCs identified for the Site include the petroleum hydrocarbons, TPHd and TPHmo, and petroleum-related VOCs such as benzene, ethylbenzene and naphthalene. The recommended remedial alternative would be selected to address these primary COCs and the other COCs identified in **Table 2-1**.

3. CLEANUP OBJECTIVES AND GOALS

3.1 Remedial Action Objectives

Medium-specific (i.e., soil, soil vapor, and groundwater) RAOs have been developed for the Site, and numerical target risk levels for the COCs have been developed to achieve the medium-specific RAOs. These medium-specific RAOs and target risk levels are included in the evaluation in this Revised FS Report, including an analysis of economic and technological feasibility in accordance with State Water Resources Control Board Resolution 92-49 and other Applicable or Relevant and Appropriate Requirements (ARARs). RAOs provide the basis to identify the recommended remedial alternative that is then addressed in the Revised RAP.

Various demarcations of acceptable risk have been established by regulatory agencies. The National Oil and Hazardous Substances Pollution Contingency Plan [NCP, 40 CFR 300] indicates that lifetime incremental cancer risks posed by a site should not exceed a range of one in one million (1×10^{-6}) to one hundred in one million (1×10^{-4}) and that noncarcinogenic chemicals should not be present at levels expected to cause adverse health effects (i.e., a Hazard Index [HI] greater than 1). In addition, other relevant guidance [USEPA, 1991] states that sites posing a cumulative cancer risk of less than 1×10^{-4} and hazard indices less than unity (1) for noncancer endpoints are generally not considered to pose a significant risk warranting remediation. The California Hazardous Substances Account Act (HSAA) incorporates the NCP by reference, and thus also incorporates the acceptable risk range set forth in the NCP. In California, the Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) regulates chemical exposures to the general population and is based on an acceptable risk level of 1×10^{-5}. The California Department of Toxic Substances Control (DTSC) considers the 1×10^{-6} risk level as the generally accepted point of departure for risk management decisions for unrestricted land use. Cumulative cancer risks in the range of 1×10^{-6} to 1×10^{-4} may therefore be considered to be acceptable, with cancer risks less than 1×10^{-6} considered *de minimis*. The risk range and target Hazard Index have been considered in developing RAOs based on human health exposures to soil and soil vapor. For groundwater and the soil leaching to groundwater pathway, water quality objectives in the Basin Plan to protect the designated beneficial uses, including municipal supply, have been considered.

The following RAOs are proposed for the Site based on the above and site-specific considerations:

- Prevent human exposures to concentrations of COCs in soil, soil vapor, and indoor air such that total (i.e., cumulative) lifetime incremental carcinogenic risks are within the NCP risk range of 1×10^{-6} to 1×10^{-4} and noncancer Hazard Indices are less than 1 or concentrations are below background, whichever is higher. Potential human exposures include onsite residents and construction and utility maintenance workers. For onsite residents, the lower end of the NCP risk range (i.e., 1×10^{-6}) and a noncancer hazard index less than 1 have been used.

- Prevent fire/explosion risks in indoor air and/or enclosed spaces (e.g., utility vaults) due to the accumulation of methane generated from the anaerobic biodegradation of petroleum hydrocarbons in soils. Eliminate methane in the subsurface to the extent technologically and economically feasible.
- Remove or treat mobile LNAPL to the extent technologically and economically feasible, and where a significant reduction in risk to groundwater will result.
- Reduce COCs in groundwater to the extent technologically and economically feasible to achieve, at a minimum, the water quality objectives in the Basin Plan to protect the designated beneficial uses, including municipal supply.

A further consideration is to maintain residential land use of the Site and to avoid displacing residents or to avoid physically dividing the Carousel community.

3.2 Site-Specific Cleanup Goals

Medium-specific SSCGs for soil, soil vapor, and groundwater have been identified along with the results of the Revised HHRA to achieve these RAOs. The SSCGs were developed using the guidance documents and agency policies identified by RWQCB, as well as other applicable resources. RWQCB-directed SSCGs for soil and soil vapor that are used in this Revised FS Report are summarized below and are shown in **Table 3-1** and **Table 3-2,** respectively.

3.2.1 Soil

SSCGs for soil were calculated considering human health exposure pathways (i.e., risk-based SSCGs), and the leaching to groundwater pathway. Risk-based SSCGs for the residential scenario are based on: (1) frequent exposure assumptions (350 days per year) for shallow soil (e.g., from 0 to 5 feet bgs), and (2) infrequent exposure assumptions (4 days per year) for soils at depth that residents are unlikely to contact more than a few times per year (e.g., from 5 to 10 feet bgs). Risk-based SSCGs for the construction and utility maintenance worker scenario are developed assuming exposures can occur to soil at depths from 0 to 10 feet below ground surface (bgs). Soil SSCGs for the leaching to groundwater pathway are based on values provided by RWQCB. RWQCB directed

Shell to use RWQCB-revised SSCGs in preparing the Revised RAP, Revised FS Report, and Revised HHRA [LARWQCB, 2014a] and in subsequent correspondence provided corrections for the SSCGs for total petroleum hydrocarbons as motor oil (TPHmo) and benzene [LARWQCB, 2014f]. RWQCB-directed SSCGs are presented in the Revised HHRA and discussed in Section 3.2 of this Revised FS Report. The SSCGs shown in **Tables 3-1** and **3-2** support unrestricted residential land use for the Site.

A summary of the development of soil SSCGs is presented below and the SSCGs for soil are presented in **Table 3-1**:

- The Soil SSCGs for residential exposures are chemical-specific numerical values for COCs assuming a target incremental cancer risk of $1{\times}10^{-6}$ and a Hazard Quotient of 1. These numerical values are calculated for both frequent and infrequent exposure assumptions, which correspond to shallow soil (e.g., from 0 to 5 feet bgs) and deeper soil (e.g., from 5 to 10 feet bgs), respectively.
- The Soil SSCGs for construction and utility maintenance worker exposures are chemical-specific numerical values for COCs assuming a target incremental cancer risk of $1{\times}10^{-5}$ and a hazard quotient of 1. These values are developed assuming exposures can occur to soil at depths from 0 to 10 feet bgs.
- The Soil SSCGs for the leaching to groundwater pathway are chemical-specific numerical values for COCs based on protection of groundwater as provided by RWQCB [LARWQCB, 2014a, 2014f].

3.2.2 Soil Vapor

In response to comments received by RWQCB, the sub-slab soil vapor data were re-evaluated considering more recent data through May 2014, not subtracting the contributions of outdoor air from the indoor air results, and evaluating the contribution of background concentrations in an alternate quantitative manner. Based on the evaluation, an upper-bound vapor intrusion attenuation factor of 0.002 was used to derive sub-slab soil vapor SSCGs. In addition, as directed by RWQCB [RWQCB, 2014a, 2014c], a vapor intrusion attenuation factor of 0.002 was used to evaluate deeper soil vapor. The use of this default attenuation factor of 0.002 for the assessment of petroleum hydrocarbons detected in deeper soil vapor does not take into account the natural vadose-zone biodegradation that has been identified at the Site and will significantly over-estimate the potential for vapor intrusion for these data

Odor-based screening levels also have been developed and were considered. The odor-based screening levels for soil vapor published in the San Francisco Bay Regional Water Quality Control Board Environmental Screening Level documentation

[SFBRWQCB, 2013] are used. Based on the comparison of the risk based SSCGs and odor based screening levels, remedial planning to address risk-based SSCGs will also address odor concerns.

The SSCGs for construction and utility maintenance worker exposures are chemical-specific numerical values for COCs assuming a target incremental cancer risk of 1×10^{-5} and a hazard quotient of 1. These numerical SSCGs will be applied to soil vapor from 0 to 10 feet bgs. The soil vapor SSCGs are presented in **Table 3-2**.

The SSCGs for methane are the same as those presented in the Data Evaluation and Decision Matrix previously prepared for the Site. These SSCGs are consistent with DTSC's guidance for addressing methane detected at school sites [Cal-EPA DTSC, 2005].

Methane Level	Response
> 10%LEL (> 5,000 ppmv or 0.5%) Soil vapor pressure > 13.9 in H_2O	Evaluate engineering controls
> 2% - 10%LEL (> 1,000 - 5,000 ppmv) Soil vapor pressure > 2.8 in H_2O	Perform follow-up sampling and evaluate engineering controls

3.2.3 Groundwater

Because no current or future use of the Shallow Zone and Gage aquifer at or near the Site is anticipated due to high total dissolved solids and other water quality issues, as well as the restrictive controls on groundwater production associated with the adjudication of the West Basin and fully built-out nature of the Site, the following groundwater SSCGs are proposed for the Site (consistent with the RAOs):

- Remove mobile LNAPL to the extent technologically and economically feasible, and where a significant reduction in risk to groundwater will result from hydraulic recovery of LNAPL.[1]
- Reduce concentrations of Site-related COCs in groundwater to the extent technologically and economically feasible to achieve, at a minimum, the water quality objectives in the Basin Plan to protect the designated beneficial uses, including municipal supply.

[1] The Interstate Technology & Regulatory Council (ITRC) defines mobile LNAPL as LNAPL that exists in the soil matrix in amounts that exceed residual saturation and thus can accumulate in monitoring wells [ITRC, 2009a]. Mobile LNAPL is not necessarily migrating.

3.2.4 Cumulative Risk and Potential Leaching to Groundwater Analysis using SSCGs

The SSCGs presented above were used to evaluate potential human health risk or potential for leaching to groundwater. The SSCG values were used to calculate cumulative incremental lifetime cancer risk (ILCR) and noncancer Hazard Index (HI) estimates for each property and the streets for the exposure pathways and media presented above. For potential leaching to groundwater, the SSCGs were compared to the property-specific and street soil data as well.

The results of the cumulative ILCR and noncancer HI evaluation as well as the evaluation of potential leaching to groundwater were combined to form an overall risk characterization of each property. Properties that did not meet the RAOs based on these analyses were identified for further evaluation in the Revised FS Report and Revised RAP.

3.3 Properties Proposed for Remediation

The results of the HHRA are presented graphically on **Figures 3-1, 3-2,** and **3-4.** **Table 3-1** presents the property addresses that exceeded the lower bound of the risk management range for ILCR and a noncancer hazard index of 1 for soil and sub-slab soil vapor, respectively. Soil leaching to groundwater and metals present above background also are considered. These properties along with impacts in the Streets are identified as not meeting the RAOs established for the Site and are considered further in this Revised FS Report. In addition, in response to RWQCB comments, soils between 5 and 10 feet bgs have been included for consideration in the Revised FS Report and Revised RAP for targeted excavation as shown in **Figure 3-3**. The number of properties identified for remediation consideration is as follows:

Medium	Depth	Number of Properties Considered in RAP
Soil	≤ 5 ft bgs	202
Soil	≤ 5 ft bgs and > 5 to ≤ 10 ft bgs combined	224
Soil Vapor	Sub-slab	28[2]

[2] 27 properties were identified based on RAO exceedance for sub-slab soil vapor, and one property was identified based on methane. In addition, while the data do not indicate that vapor intrusion is an issue at any of the residences, Shell is prepared to offer installation of a sub-slab mitigation system to any of the

4. IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

4.1 Introduction

Remedial technologies that may be used to meet remedial action objectives (RAOs) presented in Section 3 of this Revised FS Report are identified and screened in this section. Technologies in remedial actions mitigate exposure either through elimination or interruption of exposure pathways or through removal of COC mass in one or more of the affected media (i.e., soil, soil vapor, or groundwater). In Section 4.2, a range of remedial technologies is identified that have potential applicability to the Site. In Section 4.3, these technologies are screened using three criteria: effectiveness, implementability, and cost. Section 4.4 sets forth a list of retained remedial technologies that are assembled into preliminary remedial alternatives in Section 5.

4.2 Identification of Remedial Technologies

4.2.1 Technologies that Interrupt the Human Health Exposure Pathway

The following technologies interrupt the human health exposure pathway:

- Sub-slab vapor intrusion mitigation, which may include the installation of passive barriers, passive venting, or active sub-slab depressurization.
- Capping portions of the Site, which involves the placement of cover material over the impacted media.
- Removal of all Site features.
- Institutional controls, which restrict access to impacted media.

Each of these technologies is discussed in the following subsections.

4.2.1.1 Sub-slab Vapor Intrusion Mitigation

Sub-slab vapor intrusion mitigation can take several forms. Passive barriers are materials or structures installed below a building to physically block the entry of vapors. Passive barriers ideally cause soil vapor that would otherwise enter an overlying building under diffusion or pressure gradients to migrate laterally beyond the building footprint.

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homeowners in the Carousel neighborhood to alleviate concerns about potential impacts to their indoor air from the Site.

Passive venting involves placing a venting layer below a building foundation to allow soil vapor to move laterally beyond the building footprint under natural diffusion gradients (resulting from the buildup of soil vapor below the building) or pressure (thermal or wind-created) gradients.

Sub-slab depressurization (SSD) is widely considered the most practical sub-slab vapor intrusion mitigation strategy for most existing and new structures, including those with basement slabs or slab-on-grade foundations [DTSC, 2011]. SSD systems function by creating a pressure differential across the slab that favors movement of indoor air downward into the subsurface. Vapor extraction points are placed beneath the slab and vapors are extracted. This is accomplished by pulling soil vapors from beneath the slab and venting them to the atmosphere at a height above the outdoor breathing zone and away from windows and air supply intakes.

The use of sub-slab vapor intrusion mitigation technologies can be effective at interrupting the human health exposure pathway to subsurface vapor sources. As noted above, analysis of the vapor intrusion pathway presented in the Revised SSCG Report and Revised HHRA indicated that vapor intrusion is not a significant pathway at the Site, and that observed concentrations in indoor air likely are reflective of background sources. However, this technology may be considered as a protective measure based on the analysis in the Revised HHRA.

4.2.1.2 Capping Portions of the Site

Capping involves placing a protective barrier, consisting of a cover, or “cap”, over impacted material such as impacted soil. Caps do not destroy or remove contaminants. Instead, they isolate COCs and keep them in place to avoid their spread and to prevent human and ecological receptors from contacting them. Various types of caps may be employed depending on Site-specific variables. Types of Site caps may include clean soil, synthetic fibers, clay, asphalt, concrete, marker beds or layers, and chemical or other types of sprays that can solidify a Site surface. Additionally, existing covers (e.g., clean soils, concrete foundations and floor slabs of houses, sidewalks, street pavement, etc.) may provide a protective barrier to minimize the potential for exposure to impacted soil below.

4.2.1.3 Removal of All Site Features

The removal of all Site features would include the removal of all houses, landscape, hardscape, roads, and utilities through various demolition and excavation methods.

4.2.1.4 Institutional Controls

Institutional controls consist of administrative steps that may be used, in conjunction with other technologies or as a stand-alone approach, to minimize the potential for exposure and/or protect the integrity of a response action. Institutional controls are commonly utilized at sites to achieve cleanup objectives, and can take many forms [USEPA, 2012b]. At the former Kast Property, institutional controls would include reliance on existing LA County and City of Carson code provisions and permitting processes so that current and future residents are made aware of residual impacts and are restricted from exposure to residual impacts. Other land use covenants (LUCs) also may be appropriate for the Site. Under certain remedial scenarios, a new LUC would be required to prohibit residential hardscape removal, but it would not be effective absent homeowner agreement and cooperation.

While the County adopted an updated Building Code on January 1, 2014 (called the "2013 County Building Code"), and the Carson City Council approved an ordinance on February 19, 2014 adopting the 2013 County Building Code except where it conflicts with City amendments (in which case, the City amendments control), those two events left unchanged portions of the County's and the City of Carson's Building Codes that are relevant to this Revised FS Report. The Carson City Council ordinance states that "any amendment contained in the Carson Municipal Code ... shall control" where such amendment conflicts with the County Code.

Section 7003.1 of the County Building Code (both the 2011 and the 2013 versions) provides that a permit is not required for "[a]n excavation that does not exceed 50 cubic yards (38.3 m3) and complies with one of the following conditions: (a) is less than 2 feet (0.6 m) in depth; [or] (b) does not create a cut slope greater than 5 feet (1.5 m) measured vertically upward from the cut surface to the surface of the natural grade and is not steeper than 2 units horizontal to 1 unit vertical (50 percent slope)."

Under Section 8105 of the Carson Building Code, which amended the County Building Code, a grading permit is not required for "[a]n excavation which (a) is less than three (3) feet in depth below natural grade, or (b) does not create a cut slope greater than three (3) feet in height and steeper than one and one-half (1-1/2) horizontal to one (1) vertical." (City of Carson Building Code § 8105 (amending Los Angeles City Building Code § 7003.1).) This was one of the grounds on which Shell proposed in the RAP to excavate in affected areas down to three feet; excavations deeper than three feet require a permit under Section 8105 of the Carson Municipal Code. (There were other grounds for proposing excavations to three feet, including the fact that residential excavations to such depths are infrequent, and US EPA guidance documents state that testing to two feet in residential areas is protective.)

In sum, pursuant to Section 8105 of the City of Carson Building Code, anyone excavating to depths of three feet or greater must obtain a permit. The permitting requirements in place in the City of Carson support the conclusion that in the unlikely event that a resident were to excavate deeper than three feet, a permit would be required. Because excavation of soils to a depth of three feet would be accompanied by replacement with clean backfill, this measure would minimize the chance that residents will encounter impacted soil.

Although the existing institutional controls are fully protective, Shell and other responsible parties have experience with an enhancements to institutional controls programs which may be appropriate for consideration here. An example of such an enhancement is in use at the Del Amo Soil and NAPL OU site.[3]

4.2.2 Technologies that Remove COC Mass and Interrupt the Human Health Exposure Pathway

Technologies that remove COC mass in addition to interrupting the human health exposure pathway can operate through physical removal processes, such as excavation, as well as through chemical or biological processes. The following technologies have been evaluated for their capacity to remove COC mass from the Site, or to assist with implementation of another technology in removing COC mass from the Site:

[3] At the Del Amo Soil and NAPL OU site, the site remedy includes multiple layers of institutional controls (ICs) used in conjunction to protect site workers and the public from potential exposure to site contaminants. One of the layers of the ICs is called the "Permit Review IC", which is currently active as a pilot program. For this Permit Review IC, the responsible parties (including Shell), USEPA, and DTSC worked together with the City of Los Angeles to place "flags" in the Los Angeles Department of Planning's Zoning Information and Map Access System (ZIMAS) database for the parcels that make up the Del Amo site. Flags alert City staff and applicants of special conditions or restrictions that apply to a specific parcel. These flags provide information and instructions to City employees and permit applicants who propose development in identified locations that require grading/excavation or building permits. The flag informs the user that the parcel's location requires contact with EPA's project team for an environmental review. As building permit applications are reviewed by the City of Los Angeles Building and Safety Department, applicants are referred to EPA's Environmental Review Team (ERT) to review construction plans and determine whether contaminated soil or groundwater would be encountered. The ERT is currently composed of EPA, DTSC, along with the responsible parties.

With this IC pilot program, the responsible parties serve as the point of contact for permit applicants. The responsible parties conduct an initial review by obtaining information from the applicant regarding the nature of the proposed construction project, proposed land use, and locations and depths of excavations. If the proposed project involves applicable soil penetration, EPA issues a letter to the applicant that outlines specifies actions to be taken prior to or during the construction process that are necessary to protect human health and the environment, or that states that the project can proceed without further evaluation.

- Excavation:
    - Lifting and cribbing houses (assists in removing mass)
    - Temporarily moving houses (assists in removing mass)
    - Removal of residual concrete slabs if encountered
    - Selected Excavation Around Existing Structures
    - Targeted Excavation
- Soil vapor extraction (SVE)
- Bioventing
- In-situ chemical oxidation (ISCO)
- Mobile LNAPL/source removal
- Monitored natural attenuation (MNA)
- Contingency in-situ groundwater remediation:
    - Air sparging with SVE
    - Biosparging
    - Injection of oxidant (e.g., Oxygen Release Compound ®).

Each of these technologies is discussed in the following subsections.

4.2.2.1 Excavation

Excavation involves digging up impacted soils and other buried debris for above-ground treatment or for offsite disposal. Impacted soil may be excavated using standard construction equipment such as backhoes, excavator trackhoes, and hand tools, or specialized construction equipment such as track-mounted limited access auger drilling rigs. The equipment chosen depends on the areal extent, depth of excavation, the need to excavate soils immediately adjacent to structures, and whether access is limited by the presence of buildings or other structures that cannot feasibly be moved (e.g., in side yards and backyards). Removing impacted materials reduces COC mass at the Site and interrupts the human health exposure pathway. After excavation, clean backfill materials are emplaced and the impacted areas are restored.

Technologies closely related to excavation are discussed below.

4.2.2.1.1 Lifting and Cribbing Houses

Houses can be detached from their foundations and floor slabs so they can be lifted and cribbed to allow implementation of other technologies (e.g., excavation, installation of a passive barrier and/or passive venting system) beneath the footprint of the house. Cribbing to temporarily support the lifted structure would take place outside of the house footprint to allow excavation below. Lifting of houses would include cutting and capping utilities; demolition of drywall, cabinets, toilets, and tub/showers from ground level to 4 feet high; demolition of fireplaces; installation of beams that attach to each wall; unbolting walls from the building foundation; and lifting the house. The structure would then be supported on cribbing to 4 feet high to allow excavation of impacted soil; backfill with clean soil; form and pour new foundation; place the house back down on new foundation and attach; remove cribbing materials; restore interior walls, cabinets, toilets, tub/showers; replace fireplace; and reconnect utilities.

4.2.2.1.2 Temporarily Moving Houses

Houses could be temporarily moved to implement other technologies (e.g., excavation, installation of a passive barrier and/or passive venting system). This involves similar challenges to lifting and cribbing a house, except that instead of cribbing the house, the house is loaded onto a trailer and moved off the lot.

Utilization of this technology would require identification of a vacant lot nearby and procuring it for temporary house storage. Houses would need to be sectioned into pieces small enough to be moved on City streets. Security would need to be obtained to protect the house until it could be replaced on a new foundation and restored.

4.2.2.1.3 Removal of Residual Concrete Slabs

Residual concrete reservoir slabs and side walls from the former oil storage reservoirs are present beneath portions of the Site. These could be removed, along with overlying impacted soils, when encountered during excavation.

4.2.2.2 Soil Vapor Extraction (SVE)

SVE systems extract impacted vapors from below ground for treatment above ground. The vapors are removed from the unsaturated zone by applying a vacuum to soils to volatilize VOCs and volatile hydrocarbons and remove impacted vapor. SVE involves drilling one or more extraction wells into the impacted soil to a depth above the water table, which must typically be deeper than about 3 feet below the ground surface [USEPA, 2012a]. Attached to the wells is equipment (e.g., a blower or vacuum pump) that creates a vacuum. The vacuum pulls air and vapors through the soil and into the well, then to an above-ground treatment system prior to discharge to the atmosphere.

4.2.2.3 Bioventing

Bioventing is an in-situ remediation technology that enhances the ability of existing microorganisms in soil to biodegrade organic constituents adsorbed on soils in the unsaturated zone. Bioventing enhances the activity of indigenous bacteria and stimulates the natural in-situ biodegradation of contaminants in soil by supplying oxygen into the subsurface. During bioventing, oxygen may be supplied through direct air injection into impacted soil through wells, by drawing air into soils through the action of vapor extraction, or the process may proceed without added oxygen.

Bioventing primarily assists in the degradation of adsorbed fuel residuals, but also assists in the degradation of VOCs as vapors move slowly through biologically active soil. Bioventing can be used to treat all aerobically biodegradable constituents; however, it has proven to be particularly effective by comparison with SVE in remediating releases of petroleum products including gasoline, diesel fuel, kerosene, and jet fuel. Lighter products such as gasoline tend to volatilize readily and can be removed more rapidly using SVE. Heavier products such as lubricating oils generally take longer to biodegrade.

4.2.2.4 In-Situ Chemical Oxidation (ISCO)

ISCO involves the introduction of a chemical oxidant into the subsurface for the purpose of transforming groundwater or soil contaminants into less harmful chemical species. ISCO can be used to reduce contaminant mass and concentrations in soil and groundwater, reduce contaminant mass flux, and to reduce anticipated cleanup times required for MNA and other remedial options. ISCO is typically performed by drilling injection wells and directly injecting chemical oxidants into the affected soil or groundwater.

4.2.2.5 Mobile Light Non-Aqueous Phase Liquid (LNAPL) Removal

Mobile LNAPL removal in localized areas, such as through pumping at or beneath the surface of groundwater in monitoring wells or by placing sorbent socks in monitoring wells, would likely reduce source mass/concentration gradients and shorten the time over which COC concentrations would return to background or MCL levels.

4.2.2.6 Monitored Natural Attenuation (MNA)

MNA relies on naturally-occurring processes to decrease concentrations of chemical constituents in groundwater. Natural processes include a variety of physical, chemical, or biological processes which, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of constituents in groundwater. Monitoring is performed to assess the decrease in concentrations of COCs through time. Implementation of MNA is generally conducted once sources have been reduced or eliminated. With respect to Site groundwater, MNA would apply both to onsite and to offsite sources.

It should be noted that there exist upgradient sources of groundwater contamination that affect the Site, for both Site-related and non Site-related COCs [Geosntec, 2013b]. Thus, a critical component of MNA at the Site is for the overseeing agency to require remediation of upgradient groundwater contamination sources by the responsible parties.

4.2.2.7 Contingency In-Situ Groundwater Remediation

In the event MNA is not successful at reducing Site-related COCs beneath the Site following implementation of the proposed remedy (assuming upgradient sources have been removed), active groundwater remediation may be warranted. Contingency groundwater remediation of certain Site-related COCs in localized areas of groundwater (e.g., where COCs exceed 100x MCLs) has been evaluated in response to RWQCB's comments.

There are several technologies that may be used to treat the groundwater contaminants. Many of them involve pumping the groundwater to the surface to treat, which increases the potential for exposure to identified receptors and requires either discharge or reinjection of treated water. To limit exposure and management of treated water, the most likely groundwater treatment remedy for these targeted source areas will involve an in-situ treatment technology which has been widely demonstrated to be effective at reducing Site-related COCs [SWRCB, 2012]. It is likely that use of air injection or chemical oxidants into the localized areas would be employed to reduce Site-related COCs. Should in-situ groundwater treatment be warranted (i.e., if concentrations of Site-related COCs are not stable or declining following a period of MNA monitoring), a pilot test of the most appropriate in-situ technology would be conducted, and if viable, implemented at a full scale.

The following in-situ groundwater treatment technologies have been identified as most applicable to the Site:

- Air Sparging with SVE
- Biosparging
- Oxidant Injection (e.g., oxygen release compound [ORC®])

The selected technology would target the reduction of COCs concentrations in localized areas of shallow groundwater (i.e., where Site-related COCs > 100x MCLs) with the goal of achieving SSCGs over time. These technologies are well-established for remediation of groundwater containing petroleum hydrocarbons and VOCs, and therefore they are expected to be effective at the Site.

Air sparging is a recognized and effective in-situ remedial technology for removal and treatment of VOCs from impacted groundwater where COCs are present in the dissolved phase. The process involves the injection of contaminant-free air into the subsurface saturated zone to enable a phase transfer of hydrocarbons from a dissolved state to a vapor phase which is then captured and treated by SVE. Air sparging also enhances the natural attenuation processes occurring in groundwater. The process is capable of increasing dissolved oxygen (DO) concentrations up to 10 milligrams per liter (mg/L) under equilibrium conditions, which would enhance aerobic biodegradation rates of VOCs and hydrocarbons in the saturated zone. This technology would effectively remediate lighter petroleum hydrocarbons (e.g., gasoline-range hydrocarbons) that volatilize readily. When combined with SVE, the SVE system would create a vacuum in the unsaturated zone through extraction wells which pulls vapors into the well and to an above-ground treatment system prior to discharge to the atmosphere.

Biosparging is a recognized in-situ remediation technology that involves the pulsed injection of saturated oxygen into the saturated zone to significantly elevate dissolved oxygen concentrations (up to 60 mg/L), which enhances the ability of existing indigenous microorganisms to biodegrade the organic constituents in the saturated zone. Biosparging may also be combined with SVE to create a vacuum in the vadose zone through a series of extraction wells to pull vapors into the wells and subsequently to an above-ground treatment system for vapor discharge to the atmosphere. Biosparging, however, also can be operated without SVE by limiting oxygen injection volumes into the groundwater. While similar to air sparging, the biosparging process promotes biodegradation of constituents rather than volatilization. Biosparging technology would effectively remediate mid-weight petroleum hydrocarbons such as diesel-range hydrocarbons.

Injection of an oxidant such as oxygen release compound (ORC®) is another in-situ remediation technology that involves the introduction of an oxidant, in this case a phosphate-intercalated magnesium peroxide that, when hydrated, produces a controlled and continuous release of oxygen to the saturated zone. The controlled-release of oxygen to the saturated zone accelerates the development of existing indigenous microorganisms to biodegrade the organic constituents. This process involves mixing an oxidant with water to form a slurry that is pressure injected (using a pump) into the saturated zone. Once the slurry is injected into the groundwater, tiny oxidant particles can produce a controlled-release of oxygen. Oxidant can also be delivered via filter socks placed in wells. When filter socks are exhausted, spent socks are replaced with new filter socks containing the slurry to restore oxygen supply to promote biodegradation of remaining organic constituents. Similar commercially-available oxidants could also be used. Injection of chemical oxidants into the saturated zone would be conducted in accordance with applicable RWQCB waste discharge requirements (WDRs).

4.3 Screening of Remedial Technologies

In this section, potential remedial technologies are screened on the basis of effectiveness, implementability, and cost. **Table 4-1** shows identified remedial technologies, screening criteria, and screening results.

4.3.1 Sub-Slab Vapor Intrusion Mitigation

Based on a multiple-lines-of-evidence evaluation, there does not appear to be a measurable contribution of COCs from sub-slab vapor to indoor air. Nevertheless, sub-slab vapor intrusion mitigation at a limited number of properties where sub-slab soil vapor concentrations exceed soil vapor RAOs is technologically implementable, effective as a protective measure, and cost-effective. It has been retained for inclusion in remedial alternatives.

4.3.2 Capping Portions of the Site

As a technology, capping can be quite effective at interrupting the human health exposure pathway. It would not reduce the mass of COCs present in Site soils, but capping would reduce infiltration and potential migration of COCs to groundwater. Capping is technologically implementable, effective, and cost-effective. Capping has been retained for inclusion in remedial alternatives.

4.3.3 Removal of All Site Features

The removal of all Site features to facilitate the use of other remedial technologies (e.g., excavation or capping) would be effective. This alternative would be very difficult to implement. Every resident within the Site would have to agree to relocate and all 285 houses would be razed. If some homeowners declined to move, the presence of some residents would make it untenable to remove all of the surrounding houses, streets and utilities. Permits for this remedial alternative would be difficult to obtain. COC-impacted and non-impacted soil, as well as other construction debris from the razed structures (including asbestos), would be hauled to or from the Site by truck or by a newly-constructed rail spur. It is very unlikely that this alternative would be selected due to the need for complete participation from the all homeowners and residents, the anticipated public reactions from residential and commercial areas proximate to the Site, environmental effects, traffic impacts and permitting difficulties. The removal of all Site features, however, has been retained for consideration in remedial alternatives to assess feasibility associated with a potential change in end land use.

4.3.4 Institutional Controls

Institutional controls already are in place for excavations 3 feet or deeper at the Site. The City of Carson Building Code Section 8105, which amends the L.A. County Building Code Section 7003.1, is an existing institutional control that would limit, through permitting processes, contact with impacted soils beneath a depth of 3 feet. This existing institutional control supports any soil excavation remedy to depths ≥ 3 feet. Because of this code provision, the City must be notified and approve excavations deeper than 3 feet. The City could readily inform residents and workers of other appropriate precautions necessary for excavations below 3 feet through existing administrative processes, and also notify Shell that monitoring and disposal may be required. Shell would coordinate with the City of Carson to establish a process through existing building and grading permit reviews, General Plan overlay or footnote, area plan, or similar process, to ensure that if a property owner were to conduct activities involving excavations greater than 3 feet deep (such as building renovation, installation of a pool or deeper landscape alterations), Shell would be notified so that the company could arrange for sampling and proper handling of impacted soils.

Because an institutional control is already in place in the City of Carson requiring grading permits in order to excavate at depths below 3 feet, these requirements would not interfere with a homeowner’s unrestricted property use and enjoyment. Depending on the selected remedy, LUCs (e.g., restrictive covenants, easements), may also be appropriate to fully implement remedial alternatives for the Site. Under certain remedial scenarios, a new LUC would be required to prohibit residential hardscape removal, but it would not be effective absent homeowner agreement and cooperation.

Anyone performing excavation is required by law to notify the Underground Service Alert one-call system. Additionally, Shell’s contractors are, and would continue to be, set up within the (USA) one-call system to receive notification of planned excavation work in the Carousel Tract. Upon notification of planned excavations, Shell or their contractors would coordinate with the entity that contacted USA (whether the homeowner or their representative, a homeowner’s contractor, or utility company such as Cal-Water, Southern California Gas Company, or AT&T) to provide monitoring and management and handling of residual soils during excavation activities.

If excavation of soil is necessary for residential or utility service provider construction activities, it is likely that impacted soil would not be suitable for reuse. If requested by the property owner or utility service provider, Shell would arrange for the removal, transportation, and offsite disposal of impacted soil by a qualified waste contractor. If potentially impacted soil is observed during urgent or emergency construction activities (e.g., a gas line repair), and an authorized representative is not onsite, Shell should be notified as early as possible to allow the material to be profiled and properly disposed. If Site soils are being excavated on an urgent basis, the property owner or contractor should take action such that potentially impacted soil is segregated and stockpiled to allow for proper soil profiling and management.

After receiving notification that potentially impacted soil could be encountered during the course of construction activities, Shell would arrange for a contractor to collect samples of the soil (either in-situ or from a segregated stockpile) for profiling purposes if an updated waste profile is needed.

To the extent possible, impacted soil would be direct-loaded into approved waste containers for transport to the appropriate recycling or disposal facility. With advance notice, Shell would provide suitable containers based on the nature of the excavation work being conducted. In the event that it is necessary to temporarily stockpile soil onsite before loading, soils should be placed upon plastic sheeting and covered with plastic until they could be loaded into approved waste containers to be provided by the responsible party.

Excavated impacted soil would be transported offsite to appropriately licensed recycling/disposal facilities by a state-licensed waste hauler for appropriate recycling or disposal. To the extent possible, soils would be pre-profiled, and approval would be obtained from the recycling/disposal facilities before excavation activities begin. Documentation pertaining to waste disposal profiles and waste disposal acceptance would be in place prior to offsite shipments of waste.

Institutional controls are technologically implementable, effective, and cost-effective. They have been retained for inclusion in remedial alternatives.

4.3.5 Excavation

Excavation of the entire Site would involve the removal of all Site features, such as houses, landscape, hardscape, roads, and utilities. While that may be technologically implementable and effective in removing impacted soils, assuming that all of the homeowners and residents agreed to permanently relocate, it could be accomplished only at exceptionally high cost, and only a limited reduction of risk would be achieved by razing of the houses and removal of the streets given that the data collected indicate an incomplete exposure pathway exists from soils beneath the houses and streets. Moreover, marginal improvement to groundwater resulting from Site-wide removal of structures would be greatly outweighed by the high economic and social costs involved. Excavation of the entire Site, however, is retained for inclusion in remedial alternatives.

4.3.5.1 Selective Excavation

By contrast with excavation of the entire Site, selective excavation of the Site around existing structures in combination with institutional controls is effective and implementable. Selective excavation would remove most of the impacted soils for which a human exposure pathway potentially is complete. During selective excavation, several considerations would minimize negative impacts. Best practices would be utilized so that utilities would be safely located and avoided, efficient equipment would be employed, materials would be handled safely, and dust, vapor, and odors would be controlled. Effective odor and vapor control can be achieved during excavation activities by using long-acting vapor suppressant foam when odorous soils are encountered.

Noise impacts to the community could be managed to below maximum allowable levels per the City noise ordinance for the majority of excavation activities when conditions allow use of sound attenuation panels. Noise levels may be exceeded when it would not be feasible to use sound attenuation panels. After excavation, restoration of landscape and hardscape would be required.

Because selective excavation is potentially effective, implementable, and economically feasible, it is retained for inclusion in remedial alternatives.

4.3.5.2 Targeted Excavation

Targeted excavation areas have been identified where, based on distribution of hydrocarbon impacts in the upper 10 feet, the potential exists for substantial hydrocarbon mass removal via deeper excavation. This concept is discussed in more detail in Section 5.2.1.

This excavation scenario entails removal of impacted soils from 5 to 10 feet bgs at residential properties in localized areas. It is recommended that these additional excavations be performed where practicable at targeted areas where constituents are present at 10 times the TPH SSCGs for leaching to groundwater or greater than the residual NAPL soil concentration (e.g., 50,000 mg/kg for TPHmo). Properties identified for targeted deeper excavation from 5 to 10 feet bgs are shown on **Figure 3-3**. Some properties were identified for excavation of both front and back yards, while others were identified for excavation of only the front or back yard.

The recommended values for definition of targeted deep excavation locations are 1,170 mg/kg for TPHg, 6,250 mg/kg for TPHd and 50,000 mg/kg for TPHmo. The TPHmo value is equal to the residual NAPL saturation concentration because 10 times the TPHmo SSCG of 10,000 mg/kg would result in a higher concentration, and typically in these instances cleanup goals are capped at residual saturation concentrations.

Although more difficult to implement than selective excavation at shallower depths, because additional deeper targeted excavation is effective in removing the most heavily TPH-impacted materials in the upper 10 feet, is effective at interrupting the leaching to groundwater pathway, and is economically feasible, it is retained for inclusion in remedial alternatives.

4.3.5.3 Lifting and Cribbing Houses

Lifting and cribbing houses, to allow for excavation beneath, is feasible in concept. However, actual implementation would be very difficult. It would require relocating the residents, moving contents out of the houses, and as described in Section 4.2.2.8, essentially demolishing the lower portion of the house to install beams that would be used to lift the house. Based on the age of the construction and experience with other houses in the community, this activity also would require asbestos and lead-based paint surveys and, potentially, abatement of asbestos. After completion of remediation work, a new foundation would be poured, the house would be replaced, and restoration would begin, which would typically take a minimum of 4 weeks for concrete curing and an additional 2 weeks for completion of utility restoration. The estimated cost to lift and crib a single story house would be approximately $25,000 to $30,000 (add an additional 20% for a two-story house), not including the estimated cost of the new foundation. The total estimated cost to restore a house would be in the range of $75,000 to $100,000 or higher. These costs do not include the estimated costs of excavation and backfill beneath the house, which would need to be done by hand. Backfill materials alone would cost about $21,000 per house. The hand-excavation and backfill work would be extremely hazardous to personnel performing the labor and would not be consistent with Shell’s EHS guidelines/rules. This technology has not been retained for consideration in remedial alternatives due to the safety concerns, long time for completion, the extended period of resident relocation and inconvenience, and the lack of clear benefit achieved.

4.3.5.4 Temporarily Moving Houses

Temporarily moving houses to perform remediation work beneath them is technically feasible. However, implementation would be very difficult. As with lifting and cribbing a house, moving a house would require relocating the residents, removing contents from the house, and essentially demolishing the lower portion of the house to install beams that would be used to lift the house onto a trailer, possibly in sections, and moving it to another lot. Based on the age of the construction and experience with other houses in the community, this activity would also require asbestos and lead-based paint surveys and, potentially, abatement of asbestos. After completion of remediation work, a new foundation would be poured, the house would be replaced, and restoration would begin, which would typically take a minimum of 4 weeks for concrete curing and an additional 2 weeks for completion of utility restoration. There are not existing locations within the Carousel Tract to temporarily relocate houses, and an offsite location would need to be identified and procured. The estimated costs associated with temporarily moving houses are anticipated to be similar to, or higher than, the estimated costs of lifting and cribbing houses, which are very high relative to the estimated cost of the house. The time to completion and disruption to residents would be significant while the additional benefit obtained would be minimal. This technology has not been retained for consideration in remedial alternatives due to potential safety concerns, long time for completion, the extended period of resident relocation and inconvenience, and the lack of clear benefit achieved.

4.3.5.5 Removal of Residual Concrete Slabs Where Encountered in Excavations

Per requirements in the CAO, URS prepared an assessment of the environmental impact and the feasibility of removal of residual concrete reservoir slabs [URS, 2013a]. This assessment summarized historical information regarding activities of the developer during demolition of the residual concrete slabs and reservoir sidewalls, and findings from investigations that provide information on the location, depth and condition of the slabs.

The concrete reservoir slab assessment concluded that nothing about the former reservoir slabs would indicate a specific need for their removal [URS, 2013a]. During one of the excavation pilot tests, portions of the concrete reservoir slab beneath the front yard of a property were excavated, broken up and removed. Based on the need for setbacks from existing structures, it was possible to remove the concrete reservoir base only from approximately 5.3% of the total area of the residential property where the deep pilot test excavation was conducted, and the area of slabs that could be removed from most other lots would be considerably less. The report concluded that removal of slabs beneath paved areas or houses would require the demolition of City streets and houses, which would have significant social, economic and environmental impact on the residents of the Carousel Tract and the local community. URS concluded that the concrete reservoir slabs do not require removal from an environmental or human health perspective and the impacts associated with their removal far outweigh the benefits of removal.

If remnants of the former reservoir concrete sidewalls and bases are encountered in remedial excavations, the concrete would be removed where encountered in the upper 5 feet of the excavations. At locations where targeted deeper excavations extend from 5 to 10 feet bgs, the concrete reservoir slabs would be removed where encountered, to the extent feasible. Based upon discussions with drilling contractor personnel, the limited access auger rig should be capable of drilling through concrete rubble and coring through the concrete slab. The ability to use the auger rig to remove the concrete slab would need to be proven in a pilot test. If it is not possible to safely remove the slab using this excavation technique, the concrete would not be removed in areas excavated using the auger excavation method.

RWQCB commented on the reservoir slab assessment report in its letter dated January 8, 2014. RWQCB clarified its position and revised its comments on the reservoir slab assessment in its letter of February 10, 2014 [LARWQCB, 2014b]. The reservoir slabs are addressed in this Revised FS Report based on RWQCB's clarification letter.

4.3.6 Soil Vapor Extraction (SVE)

SVE pilot tests were conducted to evaluate the potential effectiveness of using SVE to remove vapor-phase VOCs from the subsurface. Details of the SVE pilot test activities and results are in the Soil Vapor Extraction Pilot Test Report [URS, 2010b] and Final Pilot Test Summary Report – Part 1 [URS, 2013b], and Final Pilot Test Summary Report – Part 2 [URS and Geosyntec, 2013]. The SVE well configuration at the Site would be based on the average effective radius of vacuum influence (ROVI) from the pilot test results.

SVE could be operated in conjunction with a bioventing system by cycling the extraction from sets of wells within the SVE well field. Cycling of the system would promote oxygenation of the subsurface which would enhance the biodegradation of residual petroleum hydrocarbons. It is expected that recovered vapors from SVE system operation would decline through time and SVE operation could be discontinued in some wells and shifted to other parts of the Site. In this case, the wells would still need to be operated periodically to introduce oxygen to the subsurface in a bioventing mode of operation. SVE wells could be installed in City streets and on residential properties, as appropriate. The use of SVE systems is retained for consideration in remedial alternatives.

4.3.7 Bioventing

Bioventing pilot tests were conducted to evaluate the potential effectiveness of bioventing to reduce concentrations of petroleum hydrocarbon constituents at the Site. Bioventing pilot tests were conducted at six locations, four with vertical bioventing wells and two with horizontal bioventing wells installed in trenches. Results from the bioventing pilot tests are summarized in the final Bioventing Pilot Test Summary Report [Geosyntec, 2012b]. Evidence of degradation of petroleum hydrocarbons was observed during the pilot tests, indicating that bioventing is a potentially effective technology to remediate residual petroleum hydrocarbons.

Bioventing would likely work in conjunction with SVE. The most cost-effective way to implement bioventing would be to couple it with SVE and use the same wells via cyclical operation of the SVE system. Bioventing has been retained for consideration in remedial alternatives.

4.3.8 In-Situ Chemical Oxidation (ISCO)

A preliminary feasibility evaluation for ISCO was conducted at the time the Pilot Test Work Plan was prepared [URS and Geosyntec, 2011]. The preliminary feasibility evaluation concluded that sodium persulfate and ozone had greater potential for treatment of COCs than other oxidants considered. Based on this evaluation, ISCO bench-scale testing was conducted in two phases. The first phase is documented in the Technical Memorandum prepared by Geosyntec dated July 16, 2012 [Geosyntec, 2012a]. The second expanded bench-testing phase is documented in the Phase II ISCO Bench Scale Test Report [Geosyntec, 2013a].

Geosyntec concluded that effective field applications would require an excessive quantity of ozone to treat a single injection location, and that full-scale treatment would require an excessive quantity of ozone to achieve greater than 50% reduction in hydrocarbon mass. Therefore, field pilot testing of ISCO using ozone was not recommended based on both Phase I and Phase II findings. As a result, the use of ISCO is not retained for consideration in remedial alternatives.

4.3.9 Mobile Light Non-Aqueous Phase Liquid (LNAPL) Removal

Mobile LNAPL recovery will continue periodically where LNAPL has accumulated in monitoring wells (MW-3 and MW-12) to the extent technologically and economically feasible, and where a significant reduction in risk to groundwater will result. If mobile LNAPL accumulates in the future in other wells to a measurable thickness, LNAPL recovery will commence from those wells, and if LNAPL accumulates at a thickness of greater than 0.5 foot in other wells, LNAPL will also be periodically recovered from those wells using a dedicated pump. The goal for mobile LNAPL recovery would be an end point of no measurable LNAPL accumulation in monitoring wells at the Site.

LNAPL is currently being recovered from monitoring wells MW-3 and MW-12 on a monthly basis using dedicated pneumatic total fluids pumps installed in the wells. Recovered LNAPL is placed in drums which are immediately transported offsite for proper disposal. Periodic LNAPL recovery from MW-3 began on November 9, 2010, and recovery from MW-12 began on October 28, 2013. An estimated 105.9 and 9.6 gallons of LNAPL have been removed from MW-3 and MW-12, respectively, since LNAPL recovery began.

As part of the remedial actions described in this RAP, mobile LNAPL recovery will continue from wells MW-3 and MW-12 on a monthly basis, and, if LNAPL is detected at a measurable thickness in other wells in the future, monthly mobile LNAPL recovery would be initiated on these wells with sorbent socks or, if they have an LNAPL thickness of greater than 0.5 foot, with a dedicated pump. Monitoring of LNAPL and water levels, and mobile LNAPL recovery volume monitoring will continue during LNAPL recovery events. When mobile LNAPL recovery shows a declining trend in wells in which LNAPL occurs, recovery trends will be evaluated, and a recommendation may be made to RWQCB to reduce the frequency of mobile LNAPL recovery, as appropriate.

In the future, Shell proposes to assess the economic and technical feasibility of continued hydraulic recovery of mobile LNAPL using LNAPL transmissivity (Tn) as a criterion. The Interstate Technology and Regulatory Council (ITRC) suggests that hydraulic recovery systems can practically recover LNAPL where the Tn is greater than 0.1 to 0.8 ft2/day and that “Further lowering of Tn is difficult and can be inefficient; that is, it can take very long to marginally reduce Tn without much benefit in terms of reduction of LNAPL mass, migration potential, risk, or longevity” [ITRC, 2009b]. Tn will be assessed at wells exhibiting sufficient LNAPL thickness (at least 0.5 ft) using a baildown/slug test procedure as described by ASTM [2013].

Mobile LNAPL removal is retained for inclusion in remedial alternatives.

4.3.10 Groundwater Monitored Natural Attenuation (MNA)

MNA is expected to be effective, and easily implementable at a relatively low cost. If, following a period of monitoring MNA is not shown to be effective, it can supplemented with an active remedial technology (see Section 4.3.11).

MNA is listed as a common remedial approach used for Leaking Underground Fuel Tank (LUFT) sites [SWRQCB, 2012]. According to the USEPA, Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17P [USEPA, 1999], "*the most important considerations regarding the suitability of MNA as a remedy include: whether the contaminants are likely to be effectively addressed by natural attenuation processes, the stability of the groundwater contaminant plume and its potential for migration, and the potential for unacceptable risks to human health or environmental resources by the contamination. MNA should not be used where such an approach would result in either plume migration or impacts to environmental resources that would be unacceptable to the overseeing regulatory authority.* ***Therefore, sites where the contaminant plumes are no longer increasing in extent, or are shrinking, would be the most appropriate candidates for MNA remedies."*** Consistent with the USEPA Directive 9200.4-17P, the LUFT Manual [SWRQCB, 2012] indicates that the first line of evidence for natural attenuation is the use of trend analyses on historical data to demonstrate that the plume is stable or retreating.

Trend analyses and modeling were conducted in the *Revised Site Specific Cleanup Goals Report* [Geosyntec, 2013b] to assess temporal trends and the stability of the benzene plume at the Site to support the MNA approach. Results of the Monitoring and Remediation Optimization System (MAROS) analysis indicated that the benzene in Site groundwater is likely being attenuated through natural biodegradation processes and the benzene plume is stable or decreasing. This conclusion is supported by the current observed distribution of benzene in the plume, which shows significant attenuation (to non-detect or near non-detect concentrations) at the downgradient plume edge near the property boundary). The conclusion is also supported by the significant age of the plume source (more than ~50 years). In addition, the Bioscreen model simulation results [Geosyntec, 2013b] show that even without source zone reduction no significant down-gradient migration of the benzene plume is predicted. The second simulation, which assumed 80% benzene source zone mass removal (a reasonable assumption given the anticipated remedy of mobile LNAPL removal, SVE that will remove a large proportion of the leachable lighter petroleum fractions including benzene, and soil excavation), predicts that the benzene concentrations in groundwater will be degraded to below the MCL in approximately 70 years, also with no significant down-gradient migration of the benzene plume. This, of course, assumes that the overseeing agencies will be successful in stopping off-Site migration of COCs onto the Site.

In summary, MNA is an appropriate remedy for Site-related COCs in groundwater because:

- The benzene plume at the Site is limited in areal extent and is stable or declining due to natural degradation processes.
- Benzene and TPH are well-defined and generally limited to the Site (i.e., they do not extend significantly downgradient of the Site boundary) nor into the

underlying Gage aquifer with the exception of the migration of benzene presumably from the adjacent Turco site which has impacted the Gage aquifer beneath the northwest portion of the Site (benzene is collocated with TBA indicative of a gasoline release (not crude oil) in that location).

- The Shallow groundwater at the Site will not be used in the foreseeable future due to: (1) high total dissolved solids and other water quality issues unrelated to Site conditions, (2) is present in a low yield, thin aquifer; and (3) the overlying land use is completely residential without the needed open space for water production infrastructure; and (4) the groundwater basin is adjudicated limiting future extractions.
- Significant reduction of sources of Site-related COCs in the vadose zone are anticipated with any proposed Site remedy.

MNA is retained for inclusion in remedial alternatives because of its anticipated effectiveness, ease of implementation, and relatively low estimated cost.

4.3.11 Contingency In-Situ Groundwater Remediation

If, after five years of semi-annual MNA monitoring, the concentrations of Site-related COCs are increasing based on statistical analysis, contingency in-situ groundwater remediation would be considered at localized areas (i.e., where Site-related COCs exceed 100x MCLs). However, if the concentrations of Site-related COCs are stable or decreasing, the MNA program would continue and would be re-assessed after five additional years of annual groundwater monitoring.

The in-situ groundwater remediation options that are considered as a contingency in the event MNA is ineffective on its own in reducing Site-related COC concentrations are air sparging with SVE, biosparging, and oxidant injection. These technologies are considered because of their potential effectiveness at shortening the groundwater MNA timeframe over which COC concentrations would return to background or MCL levels. These technologies can be implemented with relative ease in some Site areas, but may be more difficult in others due to the location of the remediation with respect to houses at the Site.

Implementation of oxidant injection would be less disruptive to Site residents and more easily implemented than the other technologies because oxidant injection does not require the installation of conveyance pipeline and above-ground treatment facilities (assuming oxidant is delivered at the wellhead or through injection). Unlike the other in-situ technologies that deliver oxygen into the saturated zone, injection of chemical oxidants would be subject to a WDR permit. Oxidant can be injected directly into injection wells, either by pressure injection or by placement of filter socks, or through temporary injection points on a periodic basis. Similar to oxidant injection, air sparging and biosparging would require installation of injection wells, but they would also involve the installation of pipelines that would require excavation and replacement of paved streets and potential pipeline installation underneath residential properties. Existing utilities including water, sewer, gas mains and telecommunications service trunk lines, as well as SVE piping that would be installed as part of the remedy (if approved by RWQCB), would have to be avoided. Construction of pipelines and injection wells could lead to heavy vehicle congestion for residents.

The estimated costs to implement the contingency in-situ groundwater technologies would likely be moderate up front, with high O&M estimated costs. Oxidant injection is estimated to be on the low-end of the cost range. Because oxidant injection is more easily implementable and potentially effective, is at the lower end of the cost range, and results in less disruption to Site residents, it is retained for consideration in remedial alternatives. Air sparging with SVE and biosparging are not retained for future consideration due to the infrastructure requirements and potential for significant disruption to residents.

4.4 Retained Remedial Technologies

Following the screening assessment above, these technologies are retained for inclusion in preliminary remedial alternatives:

- Sub-slab vapor intrusion mitigation
- Capping
- Removal of all Site features
- Institutional controls
- Excavation
  - Selective excavation around existing structures
  - Removal of residual concrete slabs where encountered in excavations
- Soil vapor extraction (SVE)
- Bioventing
- Mobile LNAPL/source removal
- Groundwater monitored natural attenuation (MNA)
- Contingency in-situ groundwater remediation using oxidant injection (if warranted).

5. REMEDIAL ALTERNATIVES IDENTIFICATION AND SCREENING

5.1 Identification of Preliminary Alternatives

Each technology that was retained after screening would be capable of addressing a specific Site issue, but none of the technologies alone would constitute a complete approach to Site cleanup. It is necessary to combine groups of technologies to comprise a complete approach. Remedial alternatives represent such combinations of technologies. After preliminary remedial alternatives are defined, they are screened to assess which represent realistic approaches to Site cleanup.

The step of combining technologies into complete preliminary remedial alternatives, and then screening those alternatives, is conducted in this section. Following this screening step, retained remedial alternatives are subjected to detailed evaluation, which is conducted in Section 6 of this Revised FS Report.

5.2 Depth of Excavation Considerations

Alternatives 2 and 3 include excavation to a specific depth, while Alternatives 4 and 5 each include five excavation depths: 2 feet bgs, 3 feet bgs, 5 feet bgs, 5 feet bgs with additional targeted excavation to 10 feet bgs, and 10 feet bgs. A discussion of targeted excavation follows in Section 5.2.1 below. **Table 5-1** focuses on various considerations associated with excavation to these five depths for Alternatives 4 and 5. Excavation to each depth presents various property management considerations that are outlined in this table.

5.2.1 Targeted Excavation

Based upon RWQCB's direction and UCLA Expert Panel's comments, two alternatives which evaluate local targeted deeper excavation to 10 feet bgs are included in this Revised FS Report. Targeted excavation areas have been identified where, based on distribution of hydrocarbon impacts in the upper 10 feet, the potential exists for substantial hydrocarbon mass removal via deeper excavation in areas with the highest concentrations of such impacts. This excavation scenario entails removal of impacted soils from 5 to 10 feet bgs at residential properties in localized areas based on existing soil data and three-dimensional modeling as discussed in more detail in Section 5.2.3.

Properties identified for targeted deeper excavation from 5 to 10 feet bgs are shown on **Figure 3-3**. Based on the data analysis and modeling, some properties were identified for excavation of both front and back yards, while others were identified for excavation of only the front or back yard.

These additional excavations would be performed where practicable at targeted areas where constituents are present in significant amounts (i.e., at 10 times the TPH SSCGs for leaching to groundwater or greater than the residual NAPL soil concentration). The recommended values for definition of targeted deeper excavation locations are 1,170 mg/kg for TPHg, 6,250 mg/kg for TPHd and 50,000 mg/kg for TPHmo.[4] The TPHmo value is equal to the residual NAPL saturation concentration because 10 times the TPHmo SSCG of 10,000 mg/kg would result in a higher concentration and typically in these instances cleanup goals are capped at residual saturation concentrations.

The use of a 10-fold factor is based on regulatory precedents from Oregon and Massachusetts. The pertinent citations from the environmental regulations are provided in footnotes below.

The state of Massachusetts[5] defines areas of localized elevated concentrations or "hot spots" (as referenced in the regulations) as: (a) discrete areas where the average concentration within the area is greater than 10 but less than 100 times the average concentration in the immediate surrounding area, unless there is no evidence that the discrete area would be associated with greater exposure potential than the surrounding area. A discrete area where the concentration of an oil or hazardous material is greater than 100 times the concentration in the surrounding area is considered a hot spot. Thus, the recommended factor of 10 times the SSCG values is at the low end of the range used by Massachusetts.

The state of Oregon[6] defines hot spots of contamination for media other than groundwater or surface water (e.g., contaminated soil, debris, sediments, and sludges; drummed wastes; "pools" of dense, non-aqueous phase liquids submerged beneath groundwater or in fractured bedrock; and non-aqueous phase liquids floating on groundwater) as presenting a risk to human health or the environment if concentrations exceed (i) 100 times the acceptable risk level for human exposure to each individual carcinogen; (ii) 10 times the acceptable risk level for human exposure to each individual noncarcinogen; or (iii) 10 times the acceptable risk level for exposure of individual ecological receptors or populations of ecological receptors to each individual hazardous

[4] The TPHmo value is equal to the residual saturation concentration because 10 times the TPHmo SSCG of 10,000 mg/kg would result in a higher concentration and typically in these instances cleanup goals are capped at residual saturation concentrations.

[5] http://www.mass.gov/eea/agencies/massdep/cleanup/regulations/310-cmr-40-0000-mcp-subpart-a-general-provisions.html

[6] http://arcweb.sos.state.or.us/pages/rules/oars_300/oar_340/340_122.html

substance. The Oregon guidance also would support using a factor of 10 times the TPH SSCGs to define hot spots.

The areal extent of the locations at the Site were determined using results of the three dimensional modeling conducted for the Site as discussed in Section 5.2.3 and Appendix A. A horizontal slice from 5 to 10 feet bgs was taken from the 3-dimensional interpretation. This 5 to 10-foot distribution was plotted 2-dimensionally to define areas where 10 times the SSCGs for TPHg and TPHd and 50,000 mg/kg for TPHmo are exceeded. This distribution is shown on **Figure 3-3** along with properties identified for targeted deeper excavation.

In total, 82 properties were identified for targeted deeper excavation; 33 of these properties were identified for excavation in accessible portions of both front and back yards, 20 for excavation in front yards only, and 29 for excavation in back yards only. Depending on the interpreted hydrocarbon distribution, the entire accessible areas would be excavated, subject to required setback distances or in consideration of existing infrastructure (e.g., water mains, swimming pools), in some yards, and partial areas of yards would be excavated at some properties. These areas where TPH is present at greater than 10 times SSCGs for TPHg and TPHd and 50,000 mg/kg for TPHmo and identified properties are shown on **Figure 3-3**. A list of property addresses identified for deeper excavation is provided in **Table 3-3**.

5.2.2 Excavation Approach

The basic excavation protocols for all excavation alternatives would be altered as excavations are conducted to address previously unknown utilities, or concrete debris or foundations unearthed. For excavations less than 5 feet in depth, depending on the depth of excavation, and as approved by the Los Angeles County Department of Public Works (LACDPW) and City of Carson, excavations would have vertical sidewalls to maximize removal of impacted soils to the depth of excavation. Excavation sidewalls likely would be back-sloped below foundation footings of structures, although block wall footings would be removed. The alternate technique of slot trenching also could apply to shallower excavations. Excavations to 5 feet or deeper would use engineered shoring systems, slot trenching, or side slopes at the horizontal-to-vertical ratio recommended by the project geotechnical engineer and approved by the LACDPW and City of Carson in the Grading Permit for the particular property being excavated. Localized excavation from 5 to 10 feet bgs also would be conducted using a limited access auger drilling rig fitted with a bucket auger. This method may be used in tight working areas or adjacent to structures, but is still subject to certain spatial limitations.

Excavation of VOC-impacted and volatile TPH-impacted soils within the geographic area encompassed by the SCAQMD must be conducted and managed in accordance with the requirements of SCAQMD Rule 1166, Volatile Organic Compound Emissions from Decontamination of Soil. The Rule 1166 Plan would set notification, monitoring, and enforcement requirements on the work. The Rule 1166 Mitigation Plan would be obtained by the contractor selected to perform the excavation work. Additionally, the contractor retained to perform the excavation work shall have a valid OSHA Trenching Permit per 29 CFR 1926.650, 29 CFR 1926.651, and 29 CFR 1926.652 and Cal/OSHA Trenching Permit CCR Title 8 Section 341.

The following permits may be needed for excavation work:

- Grading Permits for individual properties issued by the City of Carson upon approval of grading plans by the LACDPW.
- Excavation and Encroachment Permits from the City of Carson for equipment staging and operations, lane closures in public streets, and for removal of sidewalks and excavation beneath the sidewalks in City property/easements. The City Engineering Department would require a Traffic Management Plan as part of the Encroachment Permit Application. A Trash Bin/Containers Permit also would be needed along with the Excavation and Encroachment Permit for roll-off bins if they were placed on the street.
- Excavations around existing buildings would be made with side slopes at the horizontal to vertical ratio recommended by the geotechnical engineer and approved by the LACDPW and City of Carson in the Grading Permit for the particular property being excavated. The excavation sidewalls would be back-sloped below foundation footings of structures.
- Asbestos Notifications/Abatement Permits. For properties where a house may be altered (e.g., lifting/cribbing, SSD, SVE infrastructure added), an asbestos assessment would be needed: alterations > 100 sq. ft trigger this requirement.
- Plumbing and Electrical Permits would be needed if plumbing or electrical service is removed and replaced.
- A Masonry Permit may be required for construction of replacement block walls.
- A Landscaping Permit may be required for restoration of property landscaping.

5.2.3 Estimation of TPH Mass in Proposed Excavation Areas

The mass and distribution of total petroleum hydrocarbon (TPH) in the unsaturated zone on Site were estimated using the commercial modeling software C Tech Environmental Visualization Systems expert system (EVS). The software was used to build a model of TPH distribution by interpolating TPH concentrations between locations where soil samples had been collected and analyzed. The model was used to estimate the total mass of TPH on Site by depth interval of interest and then used to estimate the mass of TPH that may be removed under excavation scenarios evaluated in this Revised FS Report. A version of the EVS software, Mining Visualization Software (MVS), was used to interpolate TPH concentrations throughout the Site by kriging. MVS is a software suite for the earth sciences that provides analysis and visualization tools. One of the main functions of the software is to interpolate data in three dimensions. Kriging is a stochastic technique that uses a linear combination of weights at known points to estimate the value at grid nodes. Additional details on both of these tools and the process used for TPH mass estimation are provided in Appendix A.

The total mass of TPH at the Site, TPH mass at the Site by depth interval, and TPH mass associated with excavation Alternatives 4B, 4C, 4D and 4E in the Revised FS were estimated from the modeled results. Estimates of mass removal for remedial alternatives required “slicing” the modeled 3D TPH volume at depth intervals of 3 feet, 5 feet, 5 feet with targeted deeper excavation to 10 feet, and 10 feet for Alternatives 4B, 4C, 4D and 4E respectively, and then comparing the estimated TPH mass of the soil expected to be removed under each alternative.

The modeled TPH mass by chemical fraction and depth interval of interest is shown below:

Depth Range (feet below ground surface)	**0 to 3**	**3 to 5**	**5 to 10**	**10 to 50**	**Total**
TPH MASS BY CHEMICAL FRACTION AND DEPTH INTERVAL - TOTAL SITE (pounds)					
TPH-gasoline (TPHg)	700	6,000	100,000	1,070,000	1,180,000
TPH-diesel (TPHd)	150,000	280,000	1,420,000	5,530,000	7,380,000
TPH-motor oil (TPHmo)	320,000	400,000	1,650,000	5,590,000	7,960,000
Total	470,000	690,000	3,170,000	12,190,000	16,500,000

TPH MASS BY CHEMICAL FRACTION WITHIN EACH DEPTH INTERVAL - TOTAL SITE (percent)					
TPHg	0.1%	1%	3%	9%	7%
TPHd	32%	41%	45%	45%	45%
TPHm	68%	58%	52%	46%	48%
Total	100%	100%	100%	100%	100%
TPH MASS BY DEPTH INTERVAL AS PORTION OF TOTAL SITE MASS - TOTAL SITE (percent)					
Total	2.8%	4.2%	19%	74%	100%

Throughout the Site at all depths, TPHg accounts for 7% of the total TPH mass and TPHd and TPHmo account for 45% and 48%, respectively. The total mass of TPH in the vadose zone (0-50 feet) was estimated to be approximately 16,500,000 pounds for all three TPH fractions. Approximately three-quarters of all TPH mass resides in the 10-50 foot range, and approximately 93% of the mass resides between 5 and 50 ft.

The modeled volume was divided into appropriate depth intervals and overlying parcels according to each remedial alternative 4B, 4C, 4D and 4E. The mass of TPH in each fraction was calculated for the volume of soil associated to be excavated under each alternative. These soil volumes and TPH masses are summarized in **Table 1.2** included in Appendix A and are presented below:

	Alternative 4B	Alternative 4C	Alternative 4D	Alternative 4E
Alternative from Feasibility Study, Residential Hardscapes Removed	**Excavation to 3 ft**	**Excavation to 5 ft**	**Excavation to 5 ft and Targeted Excavation to 10 ft**	**Excavation to 10 ft**
	Excavate 367 cubic yards per lot at 202 lots, approximately 74,000 cy	Excavate 611 cubic yards per lot at 202 lots, approximately 123,400 cy	In addition to Alternative 4C, excavate 115 front and back yards at 82 lots from 5 to 10 ft, approximately 21,000 cy	Excavate 1222 cubic yards per lot at 224 lots, approximately 273,800 cy
TPH MASS BY DEPTH INTERVAL - MASS REMOVED BY EXCAVATION				
Chemical Mass lbs[1]	200,000	480,000	1,490,000	2,020,000

EXCAVATED TPH MASS AS A PERCENTAGE OF MASS IN TOP 10 FEET OF TOTAL SITE				
Fraction Excavated	4.6%	11.1%	34.5%	46.8%
EXCAVATED TPH MASS AS A PERCENTAGE OF TOTAL SITE				
Fraction Excavated	1.2%	2.9%	9.0%	12.3%

[1] Mass removed is cumulative for each alternative.

The percentage of TPH mass reduction associated with Alternatives 4B – 4E is shown both as a percentage reduction based on the upper 10 feet of the Site and based on the upper 50 feet (roughly ground surface to groundwater) of the Site. Approximately 1% of the total mass on Site is estimated to be removed by excavating under Alternative 4B (approximately 4.6% of the upper 10 feet of the Site). Approximately 3% of the total mass on Site is estimated to be removed by excavating under Alternative 4C (approximately 11% of the upper 10 feet). Excavation under Alternative 4D (0 to 5 ft and targeted excavation to 10 ft) would remove approximately 9% of the total mass on Site and approximately 34% of the mass in the upper 10 feet. Approximately 12% of the total mass on Site is estimated to be removed by excavating under Alternative 4E (0 to 10 ft) (approximately 47% of the mass in the upper 10 feet of the Site). In general, the percentages of TPH mass removal are roughly 4 times greater if the comparison is made to mass residing only in the upper 10 feet.

Additional information on modeling methods and TPH mass calculations are described in Appendix A.

5.3 Technologies Common to Each Alternative

Alternatives 2 through 7 include some of the same technologies and one or more technologies unique to that alternative. Technologies common to many alternatives are described once, rather than describing them within each alternative:

- Institutional Controls (not used in Alternative 2)
- Sub-slab Vapor Intrusion Mitigation (not used in Alternatives 2, 3, or 6)
- SVE/Bioventing (not used in Alternative 2)
- Mobile LNAPL Removal
- Groundwater MNA
- Contingency in-situ groundwater remediation using oxidant injection (if warranted)

5.3.1 Institutional Controls

Alternatives 3 through 7 would employ institutional controls as described in Section 4.2.1.4 to restrict contact with untreated soils.

Remedial alternatives include a Surface Containment and Soil Management Plan to address notifications, management, and handling of residual soils below the depth of excavation which are impacted by COCs at concentrations greater than risk-based levels or soils beneath covered areas that are not excavated. This plan is included as an appendix to the Revised RAP [URS and Geosyntec, 2014b].

5.3.2 Sub-slab Vapor Intrusion Mitigation

Based upon the multiple lines of evidence evaluations presented in the Follow-up Indoor Air Reports and Final Interim Reports, Geosyntec and URS have concluded that constituents detected in indoor air are reflective of background sources. Notwithstanding the fact that regulatory guidance does not require remediation of COCs present at or below background levels, RWQCB directed Shell to evaluate theoretical exposures due to the vapor intrusion pathway using the detected concentrations of COCs in sub-slab soil vapor. The Revised HHRA includes this vapor intrusion evaluation and theoretical exposures were calculated using conservative assumptions (e.g., sub-slab soil vapor to indoor air attenuation factor of 0.002).

Alternatives 4, 5 and 7 employ sub-slab vapor intrusion (VI) mitigation. Active sub-slab mitigation would be implemented at properties where sub-slab soil vapor risk exceeds the corresponding RAO as identified in the Revised HHRA. Based on the HHRA results and methane detected in sub-slab soil vapor, 28 properties have been identified for sub-slab vapor mitigation (**Figure 3-4**). Twenty-seven of these properties have calculated cancer risk from sub-slab soil vapor to indoor air of greater than 1×10^{-6} and a single location is included based on the low-level methane detection that exceeds the RAO. In addition, while the data do not indicate that vapor intrusion is an issue at any of the residences, Shell is prepared to offer installation of a sub-slab mitigation system to any of the homeowners in the Carousel neighborhood to alleviate concerns about potential impacts to their indoor air from the Site.

Sub-slab depressurization (SSD) systems would be used to mitigate potential vapor intrusion at the Site. A SSD system creates a negative pressure beneath the slab of the building using a fan or similar device to remove vapor beneath the slab and exhausting the vapor above the building. This process keeps vapors emanating from soil beneath a building from entering the building. Because the SSDs would operate in an active and not a passive mode, SCAQMD would require permits for the active operation of the SSD systems.

5.3.3 SVE/Bioventing

Alternatives 3 through 7 include the addition of a combination of SVE and bioventing technologies, as described in Sections 4.2.2.2 and 4.2.2.3, respectively, to address impacted areas beneath existing hardscape, below the depth of excavation, and/or under concrete foundations of houses.

Based on the estimated quantity of extraction wells (63 nested street wells, 65 shallow zone street wells, and 486 shallow zone residential wells), it would be impractical to construct a SVE system to extract simultaneously from each of the proposed wells. Cyclic operation of the SVE system would be the most cost-effective way of implementing bioventing. SVE/bioventing could address petroleum hydrocarbons, VOCs, and methane in soil vapor. The technology would be used where appropriate based on Site investigation data to promote degradation of residual hydrocarbon concentrations where RAOs are not met. SVE/bioventing infrastructure would be installed on an estimated 221 properties and an additional 10 residences may potentially require remediation, but access to these properties for either investigation or remediation has not been granted.

Bioventing, in concert with SVE, would be used to increase oxygen levels in subsurface soils and to promote microbial activity and degradation of longer-chain petroleum hydrocarbons. Bioventing would be integral with SVE via cyclical operation of SVE wells. During periods of vapor extraction from a subset of wells, the SVE system would not only remove hydrocarbon vapors, but would also draw oxygen into the subsurface to enhance the biodegradation of residual petroleum hydrocarbons in soil. During periods when no extraction is occurring for this set of wells, remediation would be achieved through biodegradation alone (i.e., bioventing). The SVE component of this remedial measure would remove gasoline-range hydrocarbons and the lighter fractions of the diesel range hydrocarbons. Note that these TPH fractions have a greater leaching potential than the heavier TPH fractions [TPHCWG, 1997]. The bioventing component would result in biodegradation of the heavier fractions of the diesel-range hydrocarbons and motor oil-range hydrocarbons in a bioventing operational mode. The system would be designed to use the same infrastructure (i.e., extraction wells) for both SVE and bioventing, and the cyclic operating conditions would be used to implement both remedial actions. The SVE/bioventing system would be operated in manner to achieve the soil oxygen demand estimated from the bioventing pilot tests [Geosyntec, 2012b]. The time intervals and well sets for SVE would be determined based on data collected during start-up activities and may be modified based on monitoring data collected during the remedial action period.

The potential operating time for the SVE/bioventing system has been estimated based on data collected during the SVE and bioventing pilot tests [URS, 2010b; Geosyntec, 2012b]. The operating time for the SVE/bioventing system is a function of soil concentrations, TPH composition, and operating parameters (e.g., percent operating time for an individual extraction well). In general, areas with lower TPH concentrations will achieve the RAOs more quickly than areas with higher soil concentrations. SVE would be more effective at removing the lower molecular weight (i.e., more volatile) constituents present in soil. The higher molecular weight constituents will be remediated through bioventing. Based on the TPH fractionation analyses conducted as part of the Phase II Site characterization, estimates for SVE/bioventing system operating time assume that the gasoline-range hydrocarbons and the lighter fraction of the diesel-range hydrocarbons would be remediated by SVE and the heavier fraction of the diesel-range hydrocarbons and motor-oil range hydrocarbons would be remediated by bioventing.

- <u>SVE</u>: The average vapor extraction rate of the shallow wells in the SVE pilot test ranged from approximately 20 to more than 100 scfm. Assuming a ROVI of 50 feet, 10-foot treatment zone thickness, soil air-filled porosity of 0.3, and 10% operating cycle, a pore volume will be extracted every 30 days. In order to remove mass that may be in residual or sorbed phases in the vadose zone, it is assumed that 100 pore volumes of vapor extraction will be sufficient to meet the SVE remedial goals. The cyclic operation of the SVE/bioventing system will facilitate removal of mass-transport limited migration of constituents from residual or sorbed phases to the vapor phase. Based on these assumptions, the estimated SVE operating time is approximately 5 years. However, areas with higher VOC concentrations may require longer SVE system operation than areas of average or lower concentrations. Note that the remedial action objectives for protection of groundwater would be met by remediating the lower molecular weight TPH fractions which have a greater leaching potential [TPHCWG, 1997].
- <u>Bioventing</u>: The bioventing pilot test found that relatively low air flow rates (i.e., less than 1 scfm) are necessary to deliver sufficient oxygen to meet the bioventing oxygen demand. This oxygen demand would be met by implementation of the combined SVE/bioventing system described above. An estimate for the biodegradation rate for TPH in soil can be made using a stoichiometric evaluation for the amount of oxygen necessary to biodegrade residual hydrocarbons [ITRC, 2009a]. Based on the estimated flow rate of the

SVE/Bioventing system, sufficient oxygen to remediate soils with TPH concentrations of 10,000 mg/kg will be delivered to the subsurface within approximately 30 – 40 years. An alternate approach to estimate the operating time for the bioventing system is to calculate the time necessary for TPH concentrations following SVE operation to be reduced to SSCGs. Based on the distribution of TPH in soils and the remediation of gasoline-range hydrocarbons and the lighter fraction of the diesel-range hydrocarbons by SVE, soils with initial TPH concentrations of 10,000 mg/kg would likely be reduced to approximately 7,500 mg/kg (TPHd = 2,500 mg/kg and TPHmo = 5,000 mg/kg). A 40 percent reduction in these concentrations would be necessary to meet the risk-based SSCGs. Following methods presented in the bioventing pilot test summary report [Geosyntec, 2012b], a time period of 30 to 40 years of bioventing operation is estimated to achieve these remedial action objectives.

These times should be considered preliminary. Operation of the SVE/bioventing system would be optimized during implementation of the remedial action as monitoring data are collected (e.g., increase cycle time for areas with higher concentrations). Improved estimates of the potential operating time for the SVE/bioventing system could be made after analysis of these monitoring data.

The SVE/bioventing infrastructure would consist of a system of extraction/inlet wells, below-ground conveyance piping, aboveground manifolds, treatment compound(s), vapor treatment system(s), and various system controls and instrumentation. Shallow zone wells would be installed at properties requiring remediation of the shallow zone soil to meet RAOs by SVE/bioventing. Potential noise impacts from SVE operation would need to be addressed. A permit from SCAQMD would be required to install SVE/bioventing systems.

Potential offsite SVE system locations are being evaluated in terms of technological feasibility, accessibility and availability of the locations. As directed by RWQCB, three offsite locations have been identified: (1) on the former Turco Property (owned by Pedro First, Ltd., an affiliate of Black Equities Group, Ltd. and occupied by American Logistics International), (2) the business park located at 24412 So. Main Street owned by 24412 So. Main Street, LLC and managed by Surf Properties, and (3) vacant land north of the MTA/BNSF rail line owned by County Sanitation District No. 8 and leased to CBB Carson Properties and managed by SB Management Corporation, part of Black Equities Group, Ltd. Shell is currently in discussions with representatives of these three locations regarding access for system installation.

The addition of SVE and bioventing would add moderate cost to Alternatives 3 through 7.

5.3.4 Mobile LNAPL Removal

For Alternatives 2 through 7, mobile LNAPL recovery will continue periodically where LNAPL has accumulated in monitoring wells (MW-3 and MW-12) to the extent technologically and economically feasible, and where a significant reduction in risk to groundwater will result. If mobile LNAPL accumulates in the future in other wells to a measurable thickness, LNAPL recovery will commence from those wells, and if LNAPL accumulates at a thickness of greater than 0.5 foot in other wells, LNAPL will also be periodically recovered from those wells using a dedicated pump. The goal for mobile LNAPL recovery will be an end point of no measurable LNAPL accumulation in monitoring wells at the Site.

LNAPL is currently being recovered from monitoring wells MW-3 and MW-12 on a monthly basis using dedicated pneumatic total fluids pumps installed in the wells. Recovered LNAPL is placed in drums which are immediately transported offsite for proper disposal. Periodic LNAPL recovery from MW-3 began on November 9, 2010, and recovery from MW-12 began on October 28, 2013. An estimated 105.9 and 9.6 gallons of LNAPL have been removed from MW-3 and MW-12, respectively, since LNAPL recovery began.

As part of the remedial actions described in this RAP, mobile LNAPL recovery will continue from wells MW-3 and MW-12 on a monthly basis, and, if LNAPL is detected at a measurable thickness in other wells in the future, monthly mobile LNAPL recovery will be initiated on these wells with sorbent socks or, if they have an LNAPL thickness of greater than 0.5 foot, with a dedicated pump. Monitoring of LNAPL and water levels, and mobile LNAPL recovery volume monitoring will continue during LNAPL recovery events. When mobile LNAPL recovery shows a declining trend in wells in which LNAPL occurs, recovery trends will be evaluated, a recommendation may be made to RWQCB to reduce the frequency of mobile LNAPL recovery, as appropriate.

In the future, Shell proposes to assess the economic and technical feasibility of continued hydraulic recovery of mobile LNAPL using LNAPL transmissivity (Tn) as a criterion. The Interstate Technology and Regulatory Council (ITRC) suggests that hydraulic recovery systems can practically recover LNAPL where the Tn is greater than 0.1 to 0.8 ft^2/day and that "Further lowering of Tn is difficult and can be inefficient; that is, it can take very long to marginally reduce Tn without much benefit in terms of reduction of LNAPL mass, migration potential, risk, or longevity" [ITRC, 2009b]. Tn will be assessed at wells exhibiting sufficient LNAPL thickness (at least 0.5 ft) using a baildown/slug test procedure as described by ASTM [2013].

5.3.5 Groundwater MNA

For Alternatives 2 through 7, COCs in groundwater would be reduced to the extent technologically and economically feasible using source reduction in the shallow soils and/or vadose zone, mobile LNAPL removal (as discussed above), and MNA. As previously discussed, if five years of MNA monitoring (following implementation of the SVE system for Alternatives 3-7) indicate that concentrations of Site-related COCs in groundwater are not stable or decreasing, contingency in-situ groundwater remediation would be considered at localized areas (i.e., where COCs exceed 100x MCLs). Of the identified in-situ treatment alternatives, oxidant injection was retained for further evaluation as discussed below.

5.3.6 Contingency Groundwater Remediation

The annual MNA program would commence following the start-up phase of SVE/bioventing operations for Alternatives 3-7, or following completion of excavation for Alternative 2. If warranted by the results of statistical analyses conducted on the initial five years of annual MNA data, contingency remediation of certain Site-related COCs in localized areas of groundwater (i.e., where COCs exceed 100x MCLs) may be implemented utilizing oxidant injection. The purpose of the oxidant injection would be to further shorten the time over which the concentrations of COCs return to background or MCL levels if SVE/bioventing, soil excavation, mobile LNAPL removal, and natural processes are insufficient.

Oxidant (e.g., ORC®) injection could be implemented in localized Site areas to remediate volatile petroleum hydrocarbons and VOCs. The conceptual evaluation assumes use of ORC® as the oxidant, although similar commercially-available oxidants could also be used. Use of ORC®, for example, would consist of a phosphate-intercalated magnesium peroxide combined with water to create a slurry for injection into the saturated zone. The oxidant injection system would consist of a system of injection wells where oxidant is delivered at the wellhead by pressure injection or by placement of filter socks containing oxidant. The oxidant would be injected/replaced on a periodic basis as evaluated in the pilot test report. Alternatively, the oxidant could be injected in one or more rounds without wells using direct push or other technology.

The conceptual design would target injection near wells with the highest concentrations of COCs in shallow groundwater, with the injection points transecting shallow groundwater water flow. The oxidant injection volume and schedule would be optimized during operation as the rate of constituent removal would decrease when concentrations of dissolved constituents are reduced.

A pilot test would be performed to assess the ability of oxidant injection to achieve SSCGs. For conceptual design purposes, based on an estimated injection ROI of 15 feet at the Site, it is envisioned that a total of 19 oxidant injection wells or injection points would be installed in the streets with an average spacing of 30 feet (see **Figure 5-1**). If deemed necessary and if this technology is selected for groundwater remedy, a remedial design implementation plan (RDIP) providing the injection well location(s), specifications, and calculations of oxidant delivery would be submitted for RWQCB approval. The actual ROI could be measured in the field and the RDIP adjusted accordingly.

5.3.7 Long-Term Monitoring Program

RWQCB directed that Shell prepare details on post-cleanup (i.e., long-term) monitoring for alternatives that leave waste in place. This section provides an overview of the recommended long-term monitoring and sampling plan for the Site for alternatives other than Alternative 1.

5.3.7.1 Sampling of Existing Soil Vapor Probes in Streets and Utility Vaults

Alternatives 2 – 7: Quarterly monitoring of existing soil vapor probes at onsite locations and one offsite location in the streets would continue until Site conditions demonstrate it is no longer necessary. Quarterly monitoring of utility vaults would continue until after the SVE/bioventing system becomes operational and site conditions demonstrate it is no longer necessary.

5.3.7.2 SVE/Bioventing System Operational Sampling

Alternatives 4 – 7: After installation and startup of the SVE/bioventing system, periodic monitoring would be conducted for the SVE/bioventing system. Results of the analyses, in conjunction with measured flow rates, field readings and time of operation, would be used to estimate the mass of VOCs removed from the subsurface, degradation of longer-chain hydrocarbons, and as a basis for optimizing and eventual shutdown of SVE operations and switching from the SVE/bioventing to bioventing mode of operations.

Mass removal estimates would be provided to RWQCB on an annual basis. RWQCB would also be copied on reports required in the SCAQMD permit.

System operational VOC and methane monitoring data, in conjunction with system effectiveness data (see below) would be evaluated to establish when soil vapor SSCGs have been met or asymptotic concentrations have been achieved. At that time, a recommendation may be made to terminate the SVE operational mode, in which case the system operational status would change to bioventing only mode and the extraction system would only be operated periodically to induce oxygen flow to the subsurface.

5.3.7.3 Monitoring of SVE/Bioventing System Effectiveness

Alternatives 4 – 7: To monitor SVE/bioventing effectiveness, soil vapor and soil samples would be collected at 16 representative locations throughout the Site prior to start of SVE/bioventing system operation to establish baseline conditions.

- The nested or clustered soil vapor well and probe locations and soil boring locations would be specified in the RDIP. The vapor well and boring locations would be situated in between the SVE/bioventing wells so that results are not strongly influenced by close proximity to the extraction wells.
- Some of the soil vapor wells/probes would be installed near existing street soil vapor probes that are sampled quarterly, as these probes would likely be decommissioned during trenching in the street for SVE conveyance pipe installation.
- Multi-depth soil vapor probes/wells would be installed at each location.
- Sub-slab soil vapor samples would be analyzed for VOCs fixed gases (including methane).
- To reduce homeowner disruption, additional soil vapor monitoring probes/wells would not be installed on residential properties.

Following SVE/bioventing system startup, soil vapor samples would be collected from the SVE wells and soil vapor probes installed in the streets annually for 5 years and once every 5 years thereafter during system operation to monitor system effectiveness at reducing COC concentrations and degradation of longer-chain hydrocarbons.

Results of the baseline and periodic sampling would be used to evaluate overall system effectiveness as well as optimize system operation and would be reported in an initial 5-year review report and subsequent reports submitted on a 5-year basis.

Periodic measurements of vacuum at these SVE wells and soil vapor probes would be performed to evaluate and confirm the system radius of influence. If the design radius of influence is not confirmed by these vacuum readings, system operating parameters may be adjusted or installation of additional wells would be evaluated.

Soil samples would be collected from 16 soil boring locations in the streets at representative locations throughout the site using a Geoprobe rig. Boring locations would be specified in the RDIP.

After 5 years of SVE/bioventing system operation and at 5-year intervals thereafter, Geoprobe borings would be advanced and sampled at the same depths at locations adjacent to the previous borings and samples would be collected for comparative analysis with prior samples from the same locations.

Soil samples would be analyzed for TPHg, TPHd, and TPHmo by EPA Method 8015M, and VOCs by EPA Method 5035/8260B. Samples would also be extracted using the Synthetic Precipitation Leaching Procedure (SPLP) to evaluate leachability of COCs in soil and reductions in leachability over time.

5.3.7.4 Sub-Slab Soil Vapor Probe Monitoring

Alternatives 4 – 7: At the 202 properties identified for soil excavation from 0 to 5 feet bgs, sub-slab soil vapor probes would be monitored and sampled every other year for VOCs and fixed gases until remedial excavation is completed and the SVE/bioventing system becomes operational.

- After the SVE/bioventing system is fully operational, sub-slab soil vapor probes would be monitored and sampled every 5 years at the same 202 properties until site conditions demonstrate it is no longer necessary.
- Methane screening would be conducted using hand-held instruments inside the homes at the time of the sub-slab soil vapor probe sampling.
- Because outside sub-slab soil vapor probes in front and back yards would be removed along with residential hardscape, replacement probes would be installed in the garage (if one does not exist) so that two probes can be sampled per property.
- If results of sub-slab soil vapor analysis indicate that potential vapor intrusion risk exceeds 1×10^{-6} and RAOs for potential vapor intrusion are exceeded, and the property has not previously been identified for installation of sub-slab mitigation, a sub-slab depressurization system would be installed.
- If a sub-slab depressurization system has previously been installed, it would be checked to confirm it is working as designed, and if not, corrective steps such as installing a larger fan or expanding the system would be evaluated.
- To minimize impact on residents, further indoor air sampling would not be conducted unless specific conditions indicate it is warranted. Rather, Shell

recommends moving to mitigation rather than further characterization and accompanying disruption.

- Also to minimize impact on the community sub-slab sampling would be conducted over a 6 to 8-week period each year and scheduled to accommodate homeowners to the extent possible.

5.3.7.5 Sub-Slab Depressurization (SSD) Systems

Alternatives 4 – 7: The SSD monitoring program would consist of sub-slab soil vapor probe sampling at the properties where SSD systems are installed, as follows:

- One sampling event per year for years 1 through 5 following system installation.
- One sampling event every other year for years 5 through 15.
- One sampling event every five years for years 15 through 30, or until Site conditions demonstrate it is no longer necessary.

Each sampling event would consist of checking sub-slab soil vapor probes for pressure/ vacuum, and sampling two or three sub-slab soil vapor probes, depending on timing relative to hardscape removal and garage probe installation, for analysis for VOCs and fixed gases (including methane).

The SSD system would include a manometer or in-line pressure gauge to provide a simple measure that the system is operating as designed. Clear instructions (including the name and contact information for the appropriate Shell contractor) would be placed in a visible location to address problems with the SSD system operation.

Annual inspections would be done to verify that the SSD systems are operating as designed and vacuum and flow rate of the SSD fan would be monitored.

5.3.7.6 Groundwater Sampling

Alternatives 2 – 7: Following RAP approval, monitoring of both shallow zone and Gage wells would be conducted semi-annually.

Groundwater samples would be analyzed for the VOCs, TPHg, TPHd, TPHmo and metals, as well as select MNA parameters, including oxidation-reduction potential, dissolved oxygen, pH, nitrate, iron, sulfate, and methane.

The semi-annual MNA evaluation program would commence following the startup phase of the SVE system. If after five years of semi-annual MNA monitoring the concentrations of Site-related COCs exhibit an increasing trend based on statistical analysis, contingency in-situ groundwater remediation would be considered at localized areas (i.e., where Site-related COCs exceed 100x MCLs).

If concentrations of Site-related COCs are stable or decreasing, the MNA program would continue and would be re-assessed after five additional years of annual groundwater monitoring.

5.4 Assembly of Preliminary Remedial Alternatives

Technologies retained from the screening process in Section 4 were combined into preliminary remedial alternatives, as shown in **Table 5-2**. Based on the preceding evaluation of technologies, the following preliminary remedial alternatives are assembled. More discussion of the retained alternatives will follow in Section 6.0.

5.4.1 Alternative 1 – No Action Alternative

A no-action alternative would consist of no remedial actions, no institutional controls, no engineering controls, and no further monitoring of the Site. None of the technologies identified in Section 4 would be included in Alternative 1. This alternative (essentially current conditions) is included for baseline comparison against alternatives that include remedial actions.

5.4.2 Alternative 2 – Entire Site Excavation of Impacted Soils

Alternative 2 includes the removal of Site features and the excavation of impacted soils over the entire Site. **Figure 5-2** depicts the remedial actions and technologies that would be applied on a given property for Alternative 2. The term "Site features" includes houses, residential hardscape, sidewalks and roads. "Residential hardscape" includes walkways, driveways, uncovered patio areas, and hardscape associated with landscaping. Alternative 2 would require all residents within the Carousel Tract to relocate permanently.

Prior to demolition of the houses, asbestos surveys and asbestos abatement would be conducted. After the Site has been razed, impacted soils would be removed from the Site. Impacted soils are identified based on the RAOs for protection of groundwater. The previous soil samples taken at all depths would be used to identify locations where RAOs are not met and therefore require excavation, although additional sampling may be required to more thoroughly classify the Site and to determine where to excavate. Excavation likely would proceed to or near groundwater over some portions of the Site, but to an assumed 10 feet bgs over the entire Site. Depth of excavation would be dependent upon an assessment of remaining potential impacts to groundwater.

Excavated soil, residual reservoir slabs, and materials from the demolition of the houses and hardscape would be removed from the Site using either trucks or a newly-constructed rail spur. Excavated soil could not be treated onsite, because treatment of soils would significantly impact residents in properties proximate to the Site. Additionally, it would be difficult to achieve proper recompaction of soils, once treated, for reuse as Site fill. Hardscape demolition materials would be recycled offsite, and excavated soil and debris would be disposed offsite or treated offsite and recycled.

Approximately 250,000 truckloads of COC-impacted and non-impacted soil, as well as other construction debris from the razed structures (including asbestos), would be hauled to or from the Site.

Alternative 2 also includes each of the technologies below:

- Removal of Reservoir Slabs if encountered in the excavation
- Mobile LNAPL Removal
- Groundwater MNA
- Contingency Groundwater Remediation
- Long-Term Monitoring of Groundwater

The permits required for any excavation depth, identified in Section 5.2, would be required for this work. Alternate approaches to grading permitting will be discussed, such as the potential to issue blanket or blocks of Grading Permits for multiple properties that would be excavated in a phase or even the entirety of the work. The provisions discussed in Section 4.3.3 regarding the USA one-call system would be applicable to this alternative.

5.4.3 Alternative 3 – Entire Site Excavation of Impacted Soils to 10 Feet

Alternative 3 includes the removal of Site features and the excavation to a depth of 10 feet bgs over the entire Site. As a result of this action, RAOs would be met in the upper 10 feet of Site soils. **Figure 5-3** depicts the remedial actions and technologies that would be applied on a given property for Alternative 3. Site features includes houses, residential hardscape, sidewalks and roads. Alternative 3 would require all of the residents within the Carousel Tract to relocate permanently.

After the Site has been razed, it would be excavated to a depth of 10 feet bgs. Excavated soil, residual reservoir slabs, and materials from the demolition of the houses and hardscape would be removed from the Site using either trucks or a newly-constructed rail spur. Excavated soil could not be treated onsite, because treatment of soils would significantly impact residents in properties proximate to the Site.

Additionally, it would be difficult to achieve proper recompaction of soils, once treated, for reuse as Site fill. Hardscape demolition materials would be recycled offsite, and excavated soil and debris would be disposed offsite or treated offsite and recycled.

Approximately 120,000 truckloads of COC-impacted and non-impacted soil, as well as other construction debris from the razed structures (including asbestos), would be hauled to or from the Site. Institutional controls would still be required for post-remediation excavations beneath 10 feet.

Alternative 3 also includes each of the technologies below:

- Institutional Controls
- Removal of Reservoir Slabs if encountered in the excavation
- Mobile LNAPL Removal
- Groundwater MNA
- Contingency Groundwater Remediation
- Long-Term Monitoring of Groundwater

Like Alternative 2, the permits required for any excavation depth, identified in Section 5.2, would be required for this work. Alternate approaches to grading permitting will be discussed, such as the potential to issue blanket or blocks of Grading Permits for multiple properties that would be excavated in a phase or even the entirety of the work. The provisions discussed in Section 4.3.3 regarding the USA one-call system would be applicable to this alternative.

5.4.4 Alternative 4 – (Five Sub Alternatives) Excavation beneath Landscape and Hardscape

Alternative 4 consists of five sub-alternatives and includes excavation under both landscaped and residential hardscape areas as the key remedial element. **Figure 5-4** depicts the remedial actions and technologies that would be applied on a given property. The sub-alternatives include soil excavation to a depth of 2 feet bgs, 3 feet bgs, 5 feet bgs, 5 feet bgs with targeted deeper excavation to 10 feet bgs, or 10 feet bgs (Alternatives 4A, 4B, 4C, 4D, and 4E, respectively) at residential properties where RAOs are not met. Targeted deeper excavation is described in Section 5.2.1. **Table 5-1** portrays differences in excavation details for the various excavation depths.

Removal of fences and block walls may be necessary because the depth of excavation likely would exceed fencepost and footing depths. Exceptions to excavation beneath hardscape include patios covered by structures and roofs and pool decking surrounding swimming pools to avoid structural demolition and potential damage to swimming pools and appurtenant equipment. Excavation may also be limited by residence-specific features that would be assessed during development of the Property Specific Remediation Plans. No excavation would occur beneath City streets, City sidewalks, or beneath houses. City sidewalks have been eliminated from the definition of residential hardscape because, among other issues, a separate permit would be required from the City to remove these features, and because AT&T has cable vaults beneath the City sidewalks; disrupting the vaults could disrupt telecommunication in the neighborhood. In addition, because residents may not remove sidewalks without City approval, sidewalks serve as an institutional control that prevents exposure to sidewalk-covered soils.

Hardscape and landscape would be removed during the initial stage of excavation and restored to like conditions following completion of excavation. Hardscape and landscape restoration expectations would be discussed and agreed upon with the homeowner and documented before demolition takes place. Excavated soil, residual concrete slabs (where encountered during excavation), and materials from the demolition of hardscape would be removed from the Site using dump trucks. Hardscape demolition materials would be recycled offsite, and excavated soil and debris would be disposed offsite or treated offsite and recycled. As part of remedial design, an individual remediation plan would be prepared for each property.

During the Site investigation, soil samples were collected at 0.5, 2, 5 and 10 feet bgs or the depth of boring refusal. Samples were collected at other depths only if field observations indicated the presence of staining or odors in a specific boring. Analy tical data from these samples would be used to identify which properties do not meet RAOs and the number of properties that would require excavation.

Alternative 4 also includes each of the technologies below, common to each alternative, as discussed in Section 5.3:

- Institutional Controls
- Removal of Reservoir Slabs if encountered in the excavation
- Sub-slab Vapor Intrusion Mitigation
- SVE/Bioventing
- Mobile LNAPL Removal
- Groundwater MNA
- Contingency Groundwater Remediation
- Long-Term Monitoring

The permits that are identified in Section 5.2 that are required for any excavation depth and for selective excavation would be required for this work. A permit from SCAQMD would be required to install SVE/bioventing systems. The provisions discussed in Section 4.3.3 regarding the USA one-call system would be applicable to this alternative.

The general information discussed within Alternative 4 applies to Alternatives 4A – 4E; the differences among these alternatives are associated with the depth of excavation, which is addressed in the following sections.

5.4.4.1 Alternative 4A – Excavation to 2 Feet bgs

Alternative 4A consists of an excavation of shallow soils to a depth of 2 feet bgs from both landscaped areas and areas covered by residential hardscape at residential properties where human health or groundwater SSCGs are not met. Data from samples collected at depths of ≤ 2 feet bgs would be used to identify properties for excavation. The technologies common to Alternative 4 shown in Section 5.4.4 would be included in this alternative.

Table 5-1 summarizes issues that may arise based on depth of excavation and highlights differences among the effect on utilities, permitting, shoring and excavated volume. Excavating to 2 feet would require the smallest volume of soil to be removed from the Site, which would decrease the volume of soil excavated, recycled, disposed, and the amount of clean soil replaced on the Site. It would also result in the smallest amount of mass removal of the excavation alternatives considered. Shoring of the excavation would not be required for Alternative 4A.

Excavating to 2 feet would be protective of normal residential exposure. As previously described by the Expert Panel [Newfields, 2014; USEPA, 2003] has indicated that "Twenty-four (24) inches of clean soil cover is generally considered to be adequate for gardening areas…".

Excavating to 2 feet also would decrease the likelihood of coming into contact with utilities such as gas service lines and telecommunications lines. California Water Service Company (Cal-Water) mains are located 3 to 3.5 feet below ground surface, so Alternative 4A would not disturb water lines. For each property, the utilities would be mapped and may require capping, removal and/or replacement, depending on the depth of excavation and the type of utility. A resident who excavated below 2 feet could potentially come into contact with residual impacted soils. Given that the City of Carson Building Code requires a permit for excavations below 3 feet, an additional LUC or a notification system would be required to ensure notification to Shell for residential excavations between 2 and 3 feet, but it would not be effective absent homeowner agreement and cooperation.

5.4.4.2 Alternative 4B – Excavation to 3 Feet bgs

Alternative 4B consists of an excavation of shallow soils to a depth of 3 feet bgs from landscaped areas and from areas covered by residential hardscape at residential properties where human health or groundwater SSCGs are not met. The technologies common to Alternative 4 shown in Section 5.4.4 would be included in this alternative.

Data from samples collected at ≤5 feet bgs would be used to identify properties for excavation. This is a conservative approach, as it may include properties that currently meet RAOs at 3 feet bgs.

For properties that would meet RAOs based on data collected at 0.5 and 2 feet bgs but are identified for excavation based on ≤5-foot bgs data, with homeowner concurrence, additional samples may be collected at 3 feet bgs as part of remedial design to identify whether remedial excavation of these properties is needed.

Table 5-1 summarizes issues that may arise based on depth of excavation and highlights differences between the effect on utilities, permitting, shoring and volume.

As previously noted, excavating to 2 feet would be protective of normal residential exposure. As previously described by the Expert Panel [Newfields, 2014; USEPA, 2003] has indicated that "Twenty-four (24) inches of clean soil cover is generally considered to be adequate for gardening areas…". In addition, existing institutional controls would provide further protection to residents against exposures to soils below the 3-foot depth of excavation. As described in Section 4.2.1.3, the City of Carson Building Code Section 8105, which amends the L.A. County Building Code Section 7003.1, is an existing institutional control that would limit, through permitting processes, contact with impacted soils beneath a depth of 3 feet.

5.4.4.3 Alternative 4C – Excavation to 5 Feet bgs

Alternative 4C consists of an excavation of shallow soils to a depth of 5 feet bgs from both landscaped areas and areas covered by residential hardscape at residential properties where human health or groundwater SSCGs are not met. Data from the samples collected at ≤5 feet bgs would be used to identify properties for excavation. If sample data indicate that RAOs are not met at that depth, the residential hardscape of the property would be removed and excavation would occur on the exposed soils to a depth of 5 feet. The technologies common to alternatives shown in Section 5.3 would be included in this alternative.

Table 5-1 summarizes issues that may arise based on depth of excavation and highlights differences between the effect on utilities, permitting, shoring and volume.

Shoring, slot trenching, or sloped excavation sidewalls would be required for the 5-foot excavation depth of Alternative 4C. If sidewalls are sloped, residual impacted soil within the 5-foot excavation depth interval but outside the lower footprint of the excavation would need to be left in place.

Existing institutional controls would provide protection to residents against exposures to soils below the 3-foot depth of excavation, and would be even more protective with the 5 ft excavation associated with Alternative 4C (although the potential of a resident inadvertently coming into contact with soils below 3 feet is low). As described in Section 4.2.1.3, the City of Carson Building Code Section 8105, which amends the L.A. County Building Code Section 7003.1, is an existing institutional control that would limit, through permitting processes, contact with impacted soils beneath a depth of 3 feet.

5.4.4.4 Alternative 4D – Excavation to 5 Feet bgs with Targeted Deeper Excavation to 10 Feet bgs

lternative 4D includes an excavation of soils to a depth of 5 feet bgs from both landscaped areas and areas covered by residential hardscape at residential properties where RAOs are not met, and targeted deeper excavation to 10 feet bgs for additional mass removal. Targeted deeper excavation is described in Section 5.2.1. Such targeted deeper excavations would occur where an excavation to ≥ 5 feet already is being conducted. Such excavation could include both residential yards, or only a front yard, or only a back yard, depending on the analysis and modeling of sampling data of elevated TPH in soils > 5 feet and < 10 feet bgs. In some cases, only partial yard areas would be excavated to the greater depth.

Shoring, slot trenching, or sloped excavation sidewalls would be required for the 5-foot excavation depth of Alternative 4D. If sidewalls are sloped, residual impacted soil within the 5-foot excavation depth interval but outside the lower footprint of the excavation would need to be left in place. In some areas where targeted deeper excavation from 5 to 10 feet is conducted, a limited access bucket auger drilling rig would be used in conjunction with conventional excavation equipment. Conventional excavation using slot-trenching as necessary to protect structures or other features and open bulk excavation with appropriate sloping, setbacks, and/or shoring would be used where possible as the preferred excavation method. Auger excavation using a limited access rig has the advantage of being able to work in relatively tight spaces adjacent to structures to remove a column of soil.

Side yard and back property fences and block walls likely would need to be removed to allow excavation of adjacent properties. Hand excavation would likely be required on side yards where there is insufficient room for equipment to operate. Side yard access would be significantly improved if work can be done sequentially on adjacent properties and the fence between the side and back yards of the properties can be removed, allowing larger equipment access to back yards. With the fence removed, the available distance between adjacent structures for equipment access is 10 feet. If one of the structures has a fireplace, this available distance is reduced to 8½ feet.

As currently envisioned, excavation would proceed in phases, with each phase of work including approximately eight contiguous properties, if access can be obtained. Assuming City approval of the number of daily truck trips, excavation would occur concurrently on four of the eight properties. By excavating on four properties concurrently, the overall duration to complete remedial excavation is shortened and excavations can be accomplished more efficiently. Preliminarily, based on working five days per week, it is estimated that excavation and backfill would take approximately six weeks per property and site restoration would take an additional approximately two weeks; approximately 10 weeks needed to complete a phase of eight properties.

Data from the samples collected at ≤10 feet bgs would be used to identify properties for excavation. If analysis and modeling of sampling data indicate that RAOs are not met at a depth of <5 ft bgs, the residential hardscape of the property would be removed and excavation would occur on the exposed soils to a depth of 5 feet. Additional excavation would occur to remove soils in targeted areas to a maximum of 10 feet bgs. The technologies common to alternatives shown in Section 5.3 would be included in this alternative.

Table 5-1 summarizes issues that may arise based on depth of excavation and highlights differences between the effect on utilities, permitting, shoring and volume. Excavation to 5 feet bgs with targeted deeper excavation would require removal and replacement of fences and block walls between properties, adding to estimated cost and complexity. Additional targeted deeper excavations to 10 feet bgs would require a geotechnical investigation report for every property that is excavated to support excavation design, permitting, and establishment of necessary setbacks from buildings and sensitive utilities.

Existing institutional controls would provide protection to residents against exposures to soils below the 3-foot depth of excavation, and would be even more protective with the 5 ft excavation with targeted deeper excavations associated with Alternative 4D. As described in Section 4.2.1.3, the City of Carson Building Code Section 8105, which amends the L.A. County Building Code Section 7003.1, is an existing institutional control that would limit, through permitting processes, contact with impacted soils beneath a depth of 3 feet.

5.4.4.5 Alternative 4E – Excavation to 10 Feet bgs

Alternative 4E consists of an excavation of shallow soils to a depth of 10 feet bgs from both landscaped areas and areas covered by hardscape at residential properties where human health or groundwater SSCGs are not met.[7] Data from the sampling that occurred at ≤10 feet bgs would be used to identify properties for excavation. If analysis and modeling of sampling data indicate that soils on a given property do not meet RAOs, the residential hardscape of the property would be removed and excavation would occur to remove exposed soils to the depth where the deepest exceedance took place. The technologies common to alternatives shown in Section 5.3 would be included in this alternative. SVE and bioventing infrastructure may be modified for a 10-foot excavation depth.

Shoring, slot trenching, or sloped excavation sidewalls, described for Alternative 4D, would be required more extensively for the 10-foot excavation depth of Alternative 4E. It is possible that vertical sidewalls would not be permitted at 10 feet. For the excavation pilot test, the County required backfill the same day, which would greatly complicate logistics of excavation. In some areas, a limited access bucket auger drilling rig would be used in conjunction with conventional excavation equipment. Conventional excavation using slot-trenching as necessary to protect structures or other features and open bulk excavation with appropriate sloping, setbacks, and/or shoring would be used where possible as the preferred excavation method. Auger excavation using a limited access rig has the advantage of being able to work in relatively tight spaces adjacent to structures to remove a column of soil. Many of the same yard access considerations and constraints described for Alternative 4D would apply to Alternative 4E.

Considerations regarding side yard and back property fences and block walls would be similar as described for Alternative 4D. The same concepts regarding excavation proceeding in phases described for Alternative 4D would also apply to Alternative 4E.

Table 5-1 summarizes issues that may arise based on depth of excavation and highlights differences between the effect on utilities, permitting, shoring and volume. Excavations to 10 feet bgs would require a geotechnical investigation report for every

[7] Alternative 4E in this FS Report is equivalent to Alternative 3B in the Revised SSCG Screening FS, which RWQCB directed that Shell evaluate [LARWQCB, 2014a].

property that is excavated, to support excavation design and establishment of necessary setbacks from buildings.

5.4.5 Alternative 5 – Excavation Beneath Landscape

Alternative 5 includes excavation beneath residential landscaped areas as the key remedial element. **Figure 5-5** depicts the remedial actions and technologies that would be applied on a given property for Alternative 5. There would be no excavation under residential hardscape, which differentiates Alternative 5 from Alternative 4. Soils would be excavated to a depth of 2 feet bgs, 3 feet bgs, 5 feet bgs, 5 feet bgs with additional targeted excavation to 10 feet bgs, or 10 feet bgs (Alternatives 5A, 5B, 5C, 5D, and 5E[8], respectively) at residential properties where RAOs are not met. Targeted deeper excavation is described in Section 5.2.1. **Table 5-1** portrays differences in excavation details for the various excavation depths. Excavated soil and residual concrete slabs (where encountered during excavation) would be removed from the Site using dump trucks and recycled or disposed offsite. The technologies common to alternatives shown in Section 5.3 would be included in this alternative. As part of remedial design, an individual remediation plan would be prepared for each property.

For properties that would meet RAOs based on data collected at 0.5 and 2 feet bgs but are identified for excavation based on $\leq$ 5-foot bgs data, with homeowner concurrence, additional samples may be collected at 3 feet bgs as part of remedy design to identify whether remedial excavation of these properties is needed.

The permits identified in Section 5.2 that are required for any excavation depth and for selective excavation would be required for this work. However, unlike Alternatives 4A – 4E, resident who remove hardscape at their property after completion of the remedial action could potentially come into contact with impacted soils. Given that the City of Carson Building Code requires a permit for excavations below 3 feet, an additional LUC or a notification system would be required to ensure notification to Shell for residential excavations between 2 and 3 feet, but it would not be effective absent homeowner agreement and cooperation. The provisions discussed in Section 4.3.3 regarding the USA one-call system would be applicable to this alternative.

The general information discussed within Alternative 5 would apply to Alternatives 5A – 5E; the difference among these five alternatives is the depth of excavation. The issues discussed for the different depths of excavation for Alternatives 4A – 4E (as well as

[8] Alternative 5E in this FS Report is equivalent to Alternative 4B in the Revised SSCG Screening FS, which RWQCB directed that Shell evaluate [LARWQCB, 2014a].

selection of properties and/or targeted areas at those properties where deeper excavation would occur under Alternative 4D) also would apply to Alternatives 5A – 5E, respectively, and so the discussion regarding Alternatives 5A – 5E is not repeated.

5.4.6 Alternative 6 – Cap Site

Alternative 6 would involve the removal of all Site features, including houses, roads, and utilities, in order to cap the entire Site. **Figure 5-6** depicts the remedial actions and technologies that would be applied on a given property for Alternative 6. This alternative would meet RAOs by limiting contact with soil, but would not achieve the other soil goals. However, the exposure pathway would be eliminated because residents would be relocated permanently. Assuming sources of COCs are successfully addressed through SVE/bioventing and mobile LNAPL removal, LNAPL goals would be achieved. Groundwater goals (MCLs) would be met in the long term, and background levels for groundwater would be achieved in the longer term, both through MNA. Contingency groundwater remediation (i.e., where COCs exceed 100x MCLs) would reduce the time to achieve the cleanup goals.

Alternative 6 also includes each of the technologies below discussed in Section 5.3:

- Institutional Controls
- SVE/Bioventing
- Mobile LNAPL Removal
- Groundwater MNA
- Contingency Groundwater Remediation
- Long-Term Monitoring

In addition to the permits required for any excavation depth, identified in Section 5.2, the following permits would be required for this work:

- SCAQMD permit to install the SVE/bioventing system
- Asbestos Notifications/Abatement Permits

5.4.7 Alternative 7 – Cap Exposed Soils

Alternative 7 would involve the capping of exposed soils and landscaped areas of the Site with hardscape or equivalent to prevent access to impacted soils. Capping approaches could include concrete or other impervious materials. **Figure 5-7** depicts the remedial actions and technologies that would be applied on a given property for Alternative 7. The soil vapor goals would be addressed by installation of a sub-slab depressurization system for houses where RAOs are not met for sub-slab soil vapor. Assuming sources of COCs are successfully addressed through SVE/bioventing and mobile LNAPL removal, LNAPL goals would be achieved. Groundwater goals (MCLs) would be met in the long term, and background levels for groundwater would be achieved in the longer term, both through MNA. Contingency groundwater remediation (i.e., where concentrations exceed 100x MCLs) would reduce the time to achieve the cleanup goals.

The intent of this alternative would be to allow residents to remain at the Site in the long-term (following capping). The cap would be intended to prevent residential exposure to soils at the Site. Hardscape, roads and houses would remain in place during and following the capping process.

Alternative 7 also includes each of the technologies below, common to each alternative, as discussed in Section 5.3:

- Institutional Controls
- Sub-slab Vapor Intrusion Mitigation
- SVE/Bioventing
- Mobile LNAPL Removal
- Groundwater MNA
- Contingency Groundwater Remediation
- Long-Term Monitoring

Due to the nature of the proposed work, the same permits outlined for Alternative 6 would be necessary for Alternative 7.

5.5 Screening of Preliminary Remedial Alternatives

Preliminary remedial alternatives assembled in Section 5.4 are screened in this section. Three screening criteria are used. Both the short- and long-term aspects of these criteria are used to screen alternatives to assess which should continue to the detailed evaluation in Section 6:

a) Implementability
b) Effectiveness
c) Estimated cost

Implementability includes both the technical and administrative feasibility of an alternative. Technical feasibility indicates that an alternative can be designed, constructed, operated and maintained. Administrative feasibility indicates that the necessary permits can be obtained for the alternative, and staff, storage and disposal services and equipment are available. Alternatives will be classified as easy, moderate, difficult or very difficult to implement based on their technical and administrative feasibility.

Effectiveness will be evaluated based on the relative ability of an alternative to protect human health and the environment and to meet the RAOs. An alternative is considered effective if it is able to reduce the toxicity, mobility or volume of the COCs, or to mitigate exposure by eliminating a pathway. Effectiveness will be considered both during the construction/implementation phase and after remedial action is complete, which shall be termed short-term effectiveness and long-term effectiveness, respectively. Alternatives would be classified as having very low, low, moderate, or high effectiveness based on their ability to protect human health and the environment and ability to meet the RAOs.

Estimated cost would be identified as none, low, moderate, high, or very high, based on a relative comparison between the alternatives. Both operation and maintenance (O&M) and capital costs would be considered. The costs are estimated based on past projects, vendor information, cost guides and other available information.

The considerations associated with the various screening criteria for each of the alternatives are summarized in **Table 5-3**, which also indicates the areas and depths for which each cleanup goal is achieved. Conceptual costs for each alternative were roughly estimated for the purposes of comparison between the alternatives and are provided in **Table 5-3**. Proposed remedial actions and estimated costs for alternatives which remain after this screening step are evaluated in more detail in Section 6.

5.5.1 Alternative 1

Alternative 1 is the no-action alternative which includes no remedial actions, no institutional controls, no engineering controls, and no further monitoring of the Site.

Alternative 1 would be very easy to implement. There would be no engineering involved, no permits to obtain, and residents would not be disturbed. The no action alternative would not take any time to implement. Alternative 1 would not be effective at achieving the RAOs. Without source reduction in shallow soils, RAOs would not be met. No monitoring would be conducted to assess whether MNA was progressing. In the short-term, human health and the environment would not be protected from the COCs. The no-action approach would be ineffective and would not result in risk reduction for residents. It also would not be in compliance with the CAO. There is no cost associated with Alternative 1.

Although this alternative does not achieve the RAOs, it is nevertheless retained for detailed evaluation to provide a baseline for comparison against other remedial approaches, which is consistent with the National Contingency Plan (NCP).

5.5.2 Screening of Alternative 2

Alternative 2 would involve the removal of all Site features, including houses, hardscape, roads, and utilities in order to remove impacted soils through excavation. Soil would not be excavated in areas where soil concentrations are below background levels and where human health risk criteria or groundwater protection RAOs are not met.

Implementability – very difficult. Every resident would have to agree to relocate permanently and all 285 houses would be razed. If some homeowners declined to move, the presence of some residents would make it untenable to remove all of the surrounding houses, streets and utilities. Residents in the surrounding neighborhoods would also experience the disruption of the community, including impacts to the school districts. Approximately 250,000 truckloads of COC-impacted and non-impacted soil, construction debris from the razed structures (including asbestos), and clean backfill to fill the excavation, would be hauled to or from the Site by truck or by a new rail spur. The volume of soil and debris removed from the Site would consume a large amount of available landfill resources in the local region. It is very unlikely that this alternative could be implemented due to the need for complete participation from the all homeowners and residents, the anticipated public reactions from residential and commercial areas proximate to the Site, environmental effects, traffic impacts and permitting difficulties. Alternate approaches to grading permitting will be discussed, such as the potential to issue blanket or blocks of Grading Permits for multiple properties that would be excavated in a phase or even the entirety of the work. The provisions discussed in Section 4.3.3 regarding the USA one-call system would be applicable to this alternative.

In the short term, significant and possibly unmitigatable air quality, noise, and traffic impacts would occur. It is very unlikely that this remedial action would be permitted by SCAQMD or under CEQA.

Effectiveness – low. The active remedial action is estimated to take approximately 4-½ years. Alternative 2 would achieve soil goals, soil vapor goals, and nuisance goals. Groundwater impacts would be addressed through mobile LNAPL removal, MNA, and possibly contingency groundwater remediation. If warranted by the results of the statistical analyses conducted on the initial five years of annual MNA data, contingency remediation of certain Site-related COCs in localized areas of groundwater (i.e., where

COCs exceed 100x MCLs) may be implemented. However, if the concentrations of Site-related COCs are stable or decreasing, the MNA program would continue and would be re-assessed after five additional years of annual groundwater monitoring. Long-term monitoring would assess effectiveness of continuing remedial systems.

The removal of the Carousel Tract and razing of houses also would have significant long-term impacts to the City of Carson, including the loss of an established neighborhood community and a loss of tax revenue. Typically, a decrease in population leads to a decrease in tax revenues within a city; this can either be countered by increasing the tax burden placed on the remaining residents using increased tax rates, or by decreasing the quality of services provided to the community. Either of these solutions makes the City a less attractive place to live and could create a financial burden on the City of Carson. The loss of 285 households also would adversely impact nearby businesses and schools.

Estimated Cost – very high. This alternative would be the most costly of the remedial alternatives.

Conclusion – not retained. Alternative 2 is not considered technologically and economically feasible due to impractical implementability issues, and very high social, environmental, and economic costs. The decrease in risks and potential additional groundwater protection benefits from the reduction of COC mass in soils are strongly outweighed by the extremely high social, environmental, and economic costs of this alternative. Consequently, Alternative 2 is not retained for detailed evaluation.

5.5.3 Screening of Alternative 3

Alternative 3 would involve the removal of all Site features, including houses, hardscape, roads, and utilities, in order to excavate the upper 10 feet of Site soils. Unlike Alternative 2, in Alternative 3 excavation is restricted to 10 feet across the entire Site. Soil would not be excavated in areas where soil concentrations are below background levels and where human health risk criteria or groundwater protection RAOs are not met.

Implementability – very difficult. The same considerations as for Alternative 2 apply to Alternative 3. Approximately 120,000 truckloads of COC-impacted and non-impacted soil, as well as other construction debris from the razed structures (including asbestos), would be hauled to or from the Site by truck or by a newly-constructed rail spur.

Effectiveness – low. The same considerations as for Alternative 2 apply here. The active remedial action is estimated to take approximately 2.5 years.

Estimated Cost – very high. Alternative 3 estimated costs are anticipated to be very high; it is the second most expensive alternative.

Conclusion – not retained. Like Alternative 2, Alternative 3 is not considered technologically and economically feasible due to impractical implementability issues, and very high social, environmental, and economic costs. The decrease in risks and potential additional groundwater protection benefits from the reduction of COC mass in soils are strongly outweighed by the extremely high social, environmental, and economic costs of this alternative. Consequently, Alternative 3 is not retained for detailed evaluation.

5.5.4 Screening of Alternative 4A

Alternative 4A would involve excavation of shallow soils to a depth of 2 feet bgs from both landscaped areas and areas covered by residential hardscape at residential properties where human health or groundwater goals are exceeded. Excavated areas and residential hardscape would be replaced to like conditions with clean soils and new hardscape.

Implementability – high. Although this alternative would not displace the existing community, it would result in short-term inconvenience to the affected residents to excavate landscape and hardscape areas. Permission from property owners and tenants would have to be obtained to excavate all or parts of their property. Approximately 7,000 truckloads of impacted and non-impacted soil would be hauled to or from the Site. Other construction debris from the residential hardscape would also be hauled to and/or from the Site by truck. Each of the other common technologies identified in Section 5.3 would be included in this alternative.

Effectiveness – low (long term); high (short term). Excavation activities under Alternative 4A would have a very significant short-term impact on the affected residents, as their landscaping, driveways, some fencing, and other hardscape would be removed. Because those features would be replaced to like conditions following excavation and fill placement, those impacts would not be long term. Air quality, noise, and traffic impacts would be anticipated during excavation and restoration activity. Based on pilot testing, these impacts would be expected to be mitigated. The surrounding area would be impacted to a lesser extent by heavy truck traffic.

Excavating to 2 feet would be protective of normal residential exposure. As previously described by the Expert Panel [Newfields, 2014; USEPA, 2003] has indicated that "Twenty-four (24) inches of clean soil cover is generally considered to be adequate for gardening areas…". However, currently there are no existing institutional controls to address residual COCs beneath houses, and to limit access to soils between 2 feet and 3 feet bgs (although the potential for residents to contact these soils is low). Soil cleanup levels for groundwater protection (leaching to groundwater) would be met through implementation of SVE/bioventing.

The soil vapor goals would be addressed in the short-term by installation of a sub-slab depressurization system for houses where RAOs are not met for sub-slab soil vapor and in the long-term through the use of a SVE/bioventing system. There would be a moderate to high reduction in the mobility of soil vapor, with VI potential reduced through sub-slab mitigation (although the data collected do not indicate a measurable impact to indoor air from sub-slab soil vapor).

Groundwater impacts would be addressed through mobile LNAPL removal, MNA, and possibly contingency groundwater remediation. If warranted by the results of the statistical analyses conducted on the initial five years of annual MNA data, contingency remediation of certain Site-related COCs in localized areas of groundwater (i.e., where COCs exceed 100x MCLs) may be implemented. However, if the concentrations of Site-related COCs are stable or decreasing, the MNA program would continue and would be re-assessed after five additional years of annual groundwater monitoring. Long-term monitoring would assess effectiveness of continuing remedial systems. In the long term, the RAOs for groundwater would be met for the Site.

The residential remedial construction activities including excavation, on-property SVE/bioventing well and piping installation, backfill, sub-slab vapor mitigation, and Site restoration are estimated to take approximately 1.5 years to complete. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals, the SVE system may operate for a period of approximately 5 years; the bioventing system may operate for a period of approximately 30 – 40 years. Long-term monitoring would assess effectiveness of continuing remedial systems.

Estimated Cost – moderate. Alternative 4A estimated costs are anticipated to be relatively moderate.

Conclusion – not retained. Alternative 4A is considered potentially technologically and economically feasible due to the moderate degree of implementability, and moderate (primarily short term) social, environmental, and economic costs. However, residents would not be as protected against potential exposure to impacted soils in the 2-to-3-foot depth zone unless homeowners agreed to additional LUCs (such as the recording of an environmental covenant). Consequently, Alternative 4A is not retained for detailed evaluation.

5.5.5 Screening of Alternative 4B

Alternative 4B would involve excavation of shallow soils to a depth of 3 feet bgs from both landscaped areas and areas covered by residential hardscape at residential properties where human health or groundwater goals are exceeded. The excavation would also remove residual concrete slabs if encountered in excavations. Excavated areas and residential hardscape would be replaced to like conditions with clean soils and new hardscape. Each of the other common technologies identified in Section 5.3 would be included in this alternative.

Implementability – relatively high. Considerations are similar to Alternative 4A; differences are discussed below. Alternative 4B has the added difficulty of excavating an additional foot of depth. Permission from property owners and residents at 202 residences would have to be obtained. On the order of 11,000 truckloads of impacted and non-impacted soil would be hauled to or from the Site. Other construction debris from the residential hardscape would also be hauled from the Site by truck. Sub-slab mitigation (SSD) would be installed at approximately 28 houses. In addition, while the data do not indicate that vapor intrusion is an issue at any of the residences, Shell is prepared to offer installation of a sub-slab mitigation system to any of the homeowners in the Carousel neighborhood to alleviate concerns about potential impacts to their indoor air from the Site.

Effectiveness – relatively high. Considerations are similar to Alternative 4A; differences are discussed below. Impacts to the community would be higher for this alternative than for Alternative 4A because a larger soil volume would be excavated and the remedy would take longer to implement.

Alternative 4B, which includes excavation of soil to 3 feet bgs, is fully protective because of both the limited potential for residents to inadvertently contact soils below 2 feet [Newfields, 2014] and the current institutional controls in the City of Carson building code which require permits for excavation beneath 3 feet bgs. RWQCB, however commented that this institutional control does not address protecting residents from gardening or small project excavations that may encounter waste left in place beneath 3 feet bgs. As discussed in Section 4.2.1.4, Shell does not agree with RWQCB's assessment regarding institutional controls.

The residential remedial construction activities including excavation, on-property SVE/bioventing well and piping installation, backfill, sub-slab vapor mitigation, and site restoration is estimated to take approximately 2.1 years to complete. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals, the SVE system may operate for a period of approximately 5 years; the bioventing system may operate for a period of approximately 30 – 40 years. Long-term monitoring would assess effectiveness of continuing remedial systems.

Estimated Cost – moderate to high. Alternative 4B estimated costs are anticipated to be moderate to high, relative to other alternatives.

Conclusion – retained. Alternative 4B is considered potentially technologically and economically feasible due to the moderately difficult degree of implementability, high effectiveness, and moderate (primarily short term) social and environmental considerations, and moderately high economic costs. Consequently, Alternative 4B is retained for detailed evaluation.

5.5.6 Screening of Alternative 4C

Alternative 4C would involve excavation of shallow soils to a depth of 5 feet bgs from both landscaped areas and areas covered by residential hardscape at residential properties where human health or groundwater goals are exceeded. Excavated areas and residential hardscape would be replaced to like conditions with clean soils and new hardscape. Each of the other common technologies identified in Section 5.3 would be included in this alternative.

Implementability – moderate. Considerations are similar to Alternatives 4A and 4B; differences are discussed below. Alternative 4C has the added difficulty of excavating an additional two feet of depth compared with Alternative 4B. Permission from property owners and residents at 202 residences would have to be obtained. On the order of 18,000 truckloads of impacted and non-impacted soil would be hauled to or from the Site. Other construction debris from the residential hardscape would also be hauled to and/or from the Site by truck. Sub-slab depressurization (SSD) would be installed at approximately 28 houses. In addition, while the data do not indicate that vapor intrusion is an issue at any of the residences, Shell is prepared to offer installation of a sub-slab mitigation system to any of the homeowners in the Carousel neighborhood to alleviate concerns about potential impacts to their indoor air from the Site.

Not all impacted soils would be able to be removed to 5 feet bgs due to setback and sloping requirements, and the need to avoid and protect in place certain utilities (water mains). Excavation would be conducted around public water supply lines which are located about 3 to 3½ feet from the sidewalks in the front yards of approximately one-half of the properties in the Carousel Tract. These water pipes are of asbestos-cement (transite) construction. Implementation of excavation to depths of 5 feet or greater in the vicinity of the transite water main piping would be very difficult to achieve without damaging the pipes, potentially resulting in interruption of water supply to the community.

Effectiveness – high (long term); moderate (short term). Considerations are similar to Alternatives 4A and 4B; differences are discussed below. Impacts to the community would be higher for Alternative 4C than for Alternatives 4A and 4B because a larger soil volume would be excavated and the remedy would take longer to implement.

Alternative 4C, which includes excavation of soil beyond 3 feet bgs, is fully protective because of the current institutional controls in the City of Carson building code, which require permits for excavation beneath 3 feet bgs. RWQCB, however commented that this institutional control does not address protecting residents from gardening or small project excavations that may encounter waste left in place. Shell disagrees with RWQCB's assessment for reasons set forth in Section 4.2.1.4.

The residential remedial construction activities including excavation, on-property SVE/bioventing well and piping installation, backfill, sub-slab vapor mitigation, and site restoration is estimated to take approximately 4.0 years to complete. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals, the SVE system may operate for a period of approximately 5 years; the bioventing system may operate for a period of approximately 30 – 40 years. Long-term monitoring would assess effectiveness of continuing remedial systems.

Estimated Cost – high. Alternative 4C estimated costs are anticipated to be high by comparison with other alternatives.

Conclusion – retained. Alternative 4C is considered potentially technologically and economically feasible, even with the difficult degree of implementability. It has a high level of effectiveness (although not significantly greater than Alternative 4B), and moderate (primarily short term) social and environmental costs, but has high economic costs. Alternative 4C is retained for detailed evaluation.

5.5.7 Screening of Alternative 4D

Alternative 4D consists of an excavation of shallow soils to a depth of 5 feet bgs from both landscaped areas and areas covered by residential hardscape at residential properties where human health or groundwater goals are exceeded, and deeper excavation to 10 feet bgs for additional mass removal in targeted areas at those properties. Excavated areas and residential hardscape would be replaced to like conditions with clean soils and new hardscape. Each of the other common technologies identified in Section 5.3 would be included in this alternative.

Implementability – difficult. Considerations are similar to Alternative 4C; differences are discussed below. Alternative 4D has the added difficulty of excavating targeted deeper soils compared with Alternative 4C. Permission from property owners and residents at 202 residences would have to be obtained.

During initial excavation to 5 feet bgs, all soils would not be removed because of shoring, setback and sloping requirements, and the need to avoid and protect in place certain utilities (water mains). Excavation would be conducted around public water supply lines which are located about 3 to 3½ feet from the sidewalks in the front yards of approximately one-half of the properties in the Carousel Tract. These water pipes are of asbestos-cement (transite) construction. Implementation of excavation to depths of 5 feet or greater in the vicinity of the transite water main piping would be very difficult to achieve without damaging the pipes, potentially resulting in interruption of water supply to the community.

Targeted deeper excavation to 10 feet may require larger setbacks to protect structures than shallower excavations, resulting in a significantly smaller area of each property being available for excavation. Targeted deeper excavations to 10 feet would pose considerable implementation issues. Targeted deeper excavation would be done with a combination of conventional excavation and specialized auger excavation equipment. It may also involve shoring and perhaps slot trenches with vertical sidewalls. The shoring requirements would be very complex and expensive for an excavation depth of 10 feet. It is possible that vertical sidewalls would not be permitted at 10 feet. These difficulties could be mitigated to some degree with the use of specialized construction equipment such as a track-mounted limited access auger drilling rig, with the tradeoff being significant additional remediation durations and costs.

On the order of 21,000 truckloads of impacted and non-impacted soil would be hauled to or from the Site. Other construction debris from the residential hardscape would also be hauled to and/or from the Site by truck. Sub-slab mitigation (SSD) would be installed at approximately 28 houses. In addition, while the data do not indicate that vapor intrusion is an issue at any of the residences, Shell is prepared to offer installation of a sub-slab mitigation system to any of the homeowners in the Carousel neighborhood to alleviate concerns about potential impacts to their indoor air from the Site

Effectiveness – high (long term); low (short term). Considerations are similar to Alternatives 4C; differences are discussed below. Impacts to the community would be much higher for Alternative 4D than for Alternative 4C because a larger soil volume would be excavated and the remedy would take longer to implement.

Alternative 4D, which includes excavation of soil beyond 3 feet bgs, is fully protective because of the current institutional controls in the City of Carson building code which require permits for excavation beneath 3 feet bgs.

The residential remedial construction activities including excavation, on-property SVE/bioventing well and piping installation, backfill, sub-slab vapor mitigation, and Site restoration are estimated to take approximately 5.1 years to complete, assuming Shell is able to coordinate access to work at 8 adjacent properties at a time, and concurrently excavate at 4 properties. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals, the SVE system may operate for a period of approximately 5 years; the bioventing system may operate for a period of approximately 30 to 40 years. Long-term monitoring would assess effectiveness of continuing remedial systems.

Estimated Cost – high to very high. Alternative 4D estimated costs are anticipated to be high to very high by comparison with other alternatives.

Conclusion – retained. Alternative 4D is considered potentially technologically and economically feasible, even with the difficult degree of implementability. It has a high level of effectiveness (although not significantly greater than Alternative 4C), and moderate (primarily short term) social and environmental costs, but has high to very high economic costs. Alternative 4D is retained for detailed evaluation.

5.5.8 Screening of Alternative 4E

Alternative 4E consists of an excavation of shallow soils to a depth of 10 feet bgs from both landscaped areas and areas covered by hardscape at residential properties where human health or groundwater SSCGs are not met. Excavated areas and residential hardscape would be replaced to like conditions with clean soils and new hardscape. Each of the other common technologies identified in Section 5.3 would be included in this alternative.

Implementability – very difficult. Alternative 4E would be technically very difficult to implement. Excavation to 10 feet would require larger setbacks to protect structures than shallower excavations, resulting in a significantly smaller area of each property being available for excavation. Deeper excavations to 10 feet would pose considerable implementation issues and likely would require greater use of shoring to protect structures. Deeper excavation to 10 feet also may require larger setbacks to protect structures than shallower excavations, resulting in a significantly smaller area of each property being available for excavation. Excavations to 10 feet would pose considerable implementation issues. Deeper excavation would be done with a combination of conventional excavation and specialized auger excavation equipment. It may also involve shoring and perhaps slot trenches with vertical sidewalls. The shoring requirements would be very complex and expensive for an excavation depth of 10 feet. It is possible that vertical sidewalls would not be permitted at 10 feet. These difficulties could be mitigated to some degree with the use of specialized construction equipment such as a track-mounted limited access auger drilling rig, with the tradeoff being significant additional remediation durations and costs.

On the order of 40,000 truckloads of impacted and non-impacted soil would be hauled to or from the Site. Such excavation also would require more use of slurry fill and delivery by concrete trucks with placement using concrete pumpers. Permission from property owners and residents at 224 residences would have to be obtained.

Effectiveness – high (long term); very low (short term). Impacts to the community would be much higher for this alternative than for Alternative 4A, 4B, 4C, and 4D because a much larger soil volume would be excavated, the remedy would be quite onerous, and it would take significantly longer to implement at each property and throughout the neighborhood. Excavation would need to be conducted around public water supply lines, which are located about 3 to 3½ feet inside the sidewalks in the front yards of approximately one-half of the properties in the Carousel Tract. These water pipes are of asbestos-cement (transite) construction. Implementation of excavation to depths of 5 feet or greater in the vicinity of the transite water main piping would be very difficult to achieve without damaging the pipes, potentially resulting in interruption of water supply to the community.

The residential remedial construction activities including excavation, on-property SVE/bioventing well and piping installation, backfill, sub-slab vapor mitigation, and Site restoration is estimated to take approximately 7.8 years to complete. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals the SVE system may operate for a period of approximately 5 years; the bioventing system may operate for a period of approximately 30 – 40 years. Long-term monitoring would assess effectiveness of continuing remedial systems.

Alternative 4E, which includes excavation of soil beyond 3 feet bgs, is fully protective because of the current institutional controls in the City of Carson building code which require permits for excavation beneath 3 feet bgs.

Estimated Cost – very high. Alternative 4E estimated costs are anticipated to be very high relative to the estimated costs of other alternatives.

Conclusion – retained. Although the alternative is very technically difficult to implement and has significant effectiveness drawbacks, Alternative 4E will be retained for detailed evaluation as directed by RWQCB because it includes an excavation to a depth of 10 feet.

5.5.9 Screening of Alternative 5A

Alternative 5A screening would mirror Alternative 4A screening, except that residential hardscape would not be removed, nor would excavation take place beneath it. Below are other differences between Alternative 4A and 5A screening.

Implementability – high. Under Alternative 5A, on the order of 2,900 truckloads of impacted and non-impacted soil would be hauled to or from the Site. Compared with Alternative 4A, there would be less disruption to the community, less time required for implementation, less coordination on issues associated with excavation, backfill and restoration of the property.

Effectiveness – low (long term); relatively high (short term). Under Alternative 5A, there are no administrative or institutional controls restricting removal of residential hardscape after remedial action is complete. The City of Carson does not require that homeowners obtain a permit or notify the City prior to removing residential hardscape from their property. Because of the lack of a permitting or notification requirement, Alternative 5A, which does not include excavation of impacted soils beneath residential hardscape, is not expected to be as protective as Alternative 4A, which includes excavation beneath residential hardscape to 2 feet. For Alternative 5A to be protective, an additional LUC or a notification system would be required to ensure notification to Shell for residential hardscape removal or digging in the 2-to-3-foot depth zone, but it would not be effective absent homeowner agreement and cooperation.

There are, however, short-term benefits to Alternative 5A compared with Alternative 4A. Alternative 5A would pose less disruption to the residents, less time to implement, lower impacts associated with trucks and other equipment. There would be less noise/vibration without breaking up hardscape, and reduced traffic due to volume reductions without hardscape debris. It is estimated that this alternative could be implemented over approximately 1.2 years, followed by an estimated 30-year O&M period. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals the SVE system may operate for a period of approximately 5 years; the bioventing system may operate for a period of approximately 30 – 40 years. Long-term monitoring would assess effectiveness of continuing remedial systems.

Estimated Cost – moderate. Alternative 5A estimated costs are anticipated to be moderate relative to the estimated costs of other alternatives.

Conclusion – not retained. Alternative 5A is considered potentially technologically and economically feasible due to the moderate degree of implementability, and moderate (primarily short term) social, environmental, and economic costs. However, residents would not be protected against potential exposure to impacted soils in the 2-to-3-foot depth zone, nor from exposure to impacted soils beneath residential hardscape. Consequently, Alternative 5A is not retained for detailed evaluation.

5.5.10 Screening of Alternative 5B

Alternative 5B screening would mirror Alternative 4B screening, except that residential hardscape would not be removed, nor would excavation take place beneath it. Below are other differences between Alternative 4B and 5B screening.

Implementability – relatively high. Under Alternative 5B, on the order of 4,300 truckloads of impacted and non-impacted soil would be hauled to or from the Site. Compared with Alternative 4B, there would be less disruption to the community, less time required for implementation, less coordination required on issues associated with excavation, backfill and restoration of the property. Permission from property owners and residents at 202 residences would have to be obtained.

Effectiveness – moderate. Alternative 5B would not be as protective as Alternative 4B, which includes excavation beneath residential hardscape to 3 feet. As with other alternatives in the Alternative 5 group, additional LUC or a notification system would be required to ensure notification to Shell regarding cautions against residential hardscape removal, but it would not be effective absent homeowner agreement and cooperation.

The residential remedial construction activities including excavation, on-property SVE/bioventing well and piping installation, backfill, sub-slab vapor mitigation, and Site restoration is estimated to take approximately 1.6 years to complete. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals the SVE system may operate for a period of approximately 5 years; the bioventing system may operate for a period of approximately 30 – 40 years. Long-term monitoring would assess effectiveness of continuing remedial systems.

Estimated Cost – moderate. Alternative 5A estimated costs are anticipated to be moderate relative to the estimated costs of other alternatives.

Conclusion – retained. Alternative 5B is considered potentially technologically and economically feasible due to the moderately difficult degree of implementability, high effectiveness, and moderate (primarily short term) social and environmental costs and moderate economic costs. Residents would not be protected from exposure to impacted soils beneath residential hardscape. However, Alternative 5B is retained for detailed evaluation.

5.5.11 Screening of Alternative 5C

Alternative 5C screening would mirror Alternative 4C screening, except that residential hardscape would not be removed, nor would excavation take place beneath it. Below are other differences between Alternative 4C and 5C screening.

Implementability – moderate. Under Alternative 5C, on the order of 7,600 truckloads of impacted and non-impacted soil would be hauled to or from the Site. Compared with Alternative 4C, there would be less disruption to the community, less time required for implementation, less coordination on issues associated with excavation, backfill and restoration of the property. Like Alternative 4C, not all soils would be removed to 5 feet bgs due to shoring, setback and sloping requirements and the need to avoid and protect in place certain underground utilities (water mains). Excavation would be conducted around public water supply lines which are located about 3 to 3½ feet from the sidewalks in the front yards of approximately one-half of the properties in the Carousel Tract. These water pipes are of asbestos-cement (transite) construction. Implementation of excavation to depths of 5 feet or greater in the vicinity of the transite water main piping would be very difficult to achieve without damaging the pipes, potentially resulting in interruption of water supply to the community. Permission from property owners and residents at 202 residences would have to be obtained.

Effectiveness – moderate (long term); moderate (short term). Alternative 5C, which does not include excavation of impacted soils beneath residential hardscape, is not expected to be as protective as Alternative 4C, which includes excavation beneath residential hardscape to 5 feet. As with other alternatives in the Alternative 5 group, an additional LUC or a notification system would be required to ensure notification to Shell regarding cautions against residential hardscape removal, but it would not be effective absent homeowner agreement and cooperation.

The residential remedial construction activities including excavation, on-property SVE/bioventing well and piping installation, backfill, sub-slab vapor mitigation, and Site restoration is estimated to take approximately 2.8 years to complete. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals the SVE system may operate for a period of approximately 5 years; the bioventing system may operate for a period of approximately 30 – 40 years. Long-term monitoring would assess effectiveness of continuing remedial systems.

Estimated Cost – high. Alternative 5C estimated costs are anticipated to be high relative to the estimated costs of other alternatives.

Conclusion – retained. Alternative 5C is considered potentially technologically and economically feasible, even with the difficult degree of implementability. Residents would not be protected from exposure to impacted soils beneath residential hardscape. Alternative 5C has a low level of effectiveness, and moderate (primarily short term) social and environmental costs, but has high economic costs. Alternative 5C is retained for detailed evaluation.

5.5.12 Screening of Alternative 5D

Alternative 5D screening would mirror Alternative 4D screening, except that residential hardscape would not be removed, nor would excavation take place beneath it. Below are other differences between Alternative 4D and 5D screening.

Implementability – difficult. Under Alternative 5D, on the order of 9,000 truckloads of impacted and non-impacted soil would be hauled to or from the Site. Compared with Alternative 4D, there would be less disruption to the community, less time required for implementation, less coordination on issues associated with excavation, backfill and restoration of the property. Like Alternative 4D, initial excavation to 5 feet bgs would not remove all impacted soils because of shoring, setback and sloping requirements, and the need to avoid and protect in place certain sensitive utilities (water mains). Excavation would be conducted around public water supply lines which are located about 3 to 3½ feet from the sidewalks in the front yards of approximately one-half of the properties in the Carousel Tract. These water pipes are of asbestos-cement (transite) construction. Implementation of excavation to depths of 5 feet or greater in the vicinity of the transite water main piping would be very difficult to achieve without damaging the pipes, potentially resulting in interruption of water supply to the community.

Like Alternative 4D, additional targeted excavation to 10 feet may require larger setbacks to protect structures than shallower excavations, resulting in a significantly smaller area of each property being available for excavation. In addition, the very significant shoring, setback and other protections required would limit the ability to reach a depth of 10 feet in some targeted areas. These difficulties could be mitigated to some degree with the use of specialized construction equipment such as a track-mounted limited access auger drilling rig, with the tradeoff being significant additional remediation durations and costs. Permission from property owners and residents at 202 residences would have to be obtained.

Effectiveness – moderate (long term); low (short term). Alternative 5D, which does not include excavation of impacted soils beneath residential hardscape, is not expected to be as protective as Alternative 4D, which includes excavation beneath residential hardscape to 5 feet. As with other alternatives in the Alternative 5 group, an additional LUC or a notification system would be required to ensure notification to Shell regarding cautions against residential hardscape removal, but it would not be effective absent homeowner agreement and cooperation.

Impacts to the community would be much higher for this alternative than for Alternative 5A, 5B, and 5C because a larger soil volume would be excavated, the remedy would be quite onerous, and it would take significantly longer to implement at each property and throughout the neighborhood. Excavation would need to be conducted around public water supply lines, which are located about 3 to 3½ feet inside the sidewalks in the front yards of approximately one-half of the properties in the Carousel Tract. These water pipes are of asbestos-cement (transite) construction. Implementation of excavation to depths of 5 feet or greater in the vicinity of the transite water main piping would be very difficult to achieve without damaging the pipes, potentially resulting in interruption of water supply to the community.

The residential remedial construction activities including excavation, on-property SVE/bioventing well and piping installation, backfill, sub-slab vapor mitigation, and Site restoration is estimated to take approximately 2.6 years to complete. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals the SVE system may operate for a period of approximately 5 years; the bioventing system may operate for a period of approximately 30 – 40 years. Long-term monitoring would assess effectiveness of continuing remedial systems.

Estimated Cost – high. Alternative 5D estimated costs are anticipated to be high relative to the estimated costs of other alternatives.

Conclusion – retained. Alternative 5D is considered potentially technologically and economically feasible, even with the difficult degree of implementability. Residents would not be protected from exposure to impacted soils beneath residential hardscape. Alternative 5D has a low level of effectiveness, and moderate (primarily short term) social and environmental costs, but has high economic costs. Alternative 5D is retained for detailed evaluation.

5.5.13 Screening of Alternative 5E

Alternative 5E screening would mirror Alternative 4E screening, except that residential hardscape would not be removed, nor would excavation take place beneath it. Below are other differences between Alternative 4E and 5E screening.

Implementability – very difficult. Alternative 5E would be technically very difficult to implement. Excavation to 10 feet would require larger setbacks to protect structures than would shallower excavations, resulting in less area of each property being available for excavation. In addition, very significant shoring, setback and other protections required would limit the ability to reach a depth of 10 feet throughout the Site. On the order of 17,000 truckloads of impacted and non-impacted soil would be hauled to or from the Site.

Effectiveness – moderate (long term); very low (short term). Impacts to the community would be much higher for this alternative than for Alternative 5A, 5B, 5C, and 5D because a much larger soil volume would be excavated, the remedy would be quite onerous, and it would take significantly longer to implement at each property and throughout the neighborhood. Excavation would need to be conducted around public water supply lines, which are located about 3 to 3½ feet inside the sidewalks in the front yards of approximately one-half of the properties in the Carousel Tract. These water pipes are of asbestos-cement (transite) construction. Implementation of excavation to depths of 5 feet or greater in the vicinity of the transite water main piping would be very difficult to achieve without damaging the pipes, potentially resulting in interruption of water supply to the community. Permission from property owners and residents at 224 residences would have to be obtained.

The residential remedial construction activities including excavation, on-property SVE/bioventing well and piping installation, backfill, sub-slab vapor mitigation, and site restoration is estimated to take approximately 3.4 years to complete. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals the SVE system may operate for a period of approximately 5 years; the bioventing system may operate for a period of approximately 30 – 40 years. Long-term monitoring would assess effectiveness of continuing remedial systems.

Estimated Cost – high. Alternative 5E estimated costs are anticipated to be high relative to the estimated costs of other alternatives.

Conclusion – retained. Although the alternative is very technically difficult to implement and has significant effectiveness drawbacks, Alternative 5E will be retained for detailed evaluation, as directed by RWQCB because it includes an excavation to a depth of 10 feet.

5.5.14 Screening of Alternative 6

Alternative 6 would involve the removal of all Site features, and a cap over the entire Site with hardscape or equivalent. Each of the other common technologies identified in Section 5.3 would be included in this alternative, except for sub-slab vapor intrusion mitigation (not necessary because houses are removed).

Implementability – very difficult. This alternative would be very difficult to implement. Every resident would have to agree to relocate permanently, and the 285 houses would be razed. If some homeowners declined to move, the presence of some residents would make it untenable to remove surrounding houses, streets and utilities. Residents in the surrounding neighborhoods would also experience the disruption of the community, including impacts to the school districts. Approximately 12,500 truckloads of import fill and construction debris from the razed structures (including asbestos) would be hauled to or from the Site by truck or newly-constructed rail spur. This alternative also would result in generation of large quantities of stormwater that would need to be managed. The County may require stormwater to be captured and percolated, which would exacerbate groundwater contamination issues.

Alternate approaches to grading permitting will be discussed, such as the potential to issue blanket or blocks of Grading Permits for multiple properties that would be excavated in a phase or even the entirety of the work.

It is very unlikely that this alternative would be allowed to proceed due to anticipated public reactions, reactions from residential and commercial areas proximate to the Site, environmental effects, traffic impacts and permitting difficulties. In the short term, significant and possibly unmitigatable air quality, noise, and traffic impacts would occur. It is very unlikely that this remedial action would be permitted by SCAQMD and under CEQA.

Effectiveness – low. Alternative 6 would result in removal of COCs from the Site through SVE/bioventing, mobile LNAPL removal, groundwater MNA and contingency groundwater remediation. Long-term monitoring would assess effectiveness of continuing remedial systems. COCs would be less likely to leach into groundwater due to the large reduction in stormwater and irrigation water passing through the soil. The limited additional reduction in risk and minimal impact to groundwater quality when compared with other alternatives is substantially outweighed by the very high additional economic and social (including environmental) costs it would impose on the City, the surrounding residents and business owners, schools and others, as well as the difficulties associated with implementation and the substantial costs required for implementation.

The removal of the Carousel Tract and razing houses also would have significant long-term impacts to the City of Carson, including the loss of an established neighborhood community and a loss of tax revenue. Typically, a decrease in population leads to a decrease in tax revenues within a city; this can either be countered by increasing the tax burden placed on the remaining residents using increased tax rates, or by decreasing the quality of services provided to the community. Either of these solutions makes the City a less attractive place to live and could create a financial burden on the City of Carson. The loss of 285 households also would adversely impact nearby businesses and schools.

Estimated Cost – very high. The estimated cost of Alternative 6 would be very high relative to the other alternatives.

Conclusion – not retained. Alternative 6 is not considered technologically and economically feasible due to a very difficult degree of implementability, very high social and economic costs, and moderate environmental costs. Consequently, this remedial alternative is not retained for additional evaluation.

5.5.15 Screening of Alternative 7

Alternative 7 would involve the capping of exposed soils and landscaped areas of the Site with hardscape or equivalent. Each of the other common technologies identified in Section 5.3 would be included in this alternative.

Implementability – moderate. Implementation of Alternative 7 would be the easiest alternative to implement from a standpoint of the remedial actions required, but it would be difficult to implement from a standpoint of obtaining the required permits and approvals from stakeholders. Overall, this alternative would be moderately difficult to implement. The remedial activities may have a significant impact on the community in the short term during landscape removal and hardscape placement. Residents would lose existing landscaping, and future landscaping would have to be done above the cap in planter boxes. It is expected that this requirement may not be agreeable to many (or most) residents due to the permanent loss of landscaping areas. During construction, air quality, noise, and traffic impacts would be anticipated.

Effectiveness – high. Alternative 7 would result in removal of COCs from the Site through SVE/bioventing, mobile LNAPL removal, groundwater MNA, and contingency groundwater remediation. COCs would be less likely to leach into groundwater due to the large reduction in stormwater and irrigation water passing through the soil. In the long term, RAOs would be met for the Site. A new LUC would be required to prohibit residential hardscape removal, but it would not be effective absent homeowner agreement and cooperation. This alternative would also result in generation of large quantities of stormwater that would need to be managed. The County may require stormwater to be captured and percolated, which would exacerbate groundwater contamination issues. This alternative is estimated to take approximately 1.4 years to implement, followed by an estimated 30-year O&M period. Based on preliminary estimates of the duration of remediation system operation to achieve cleanup goals the SVE system is estimated to operate for a period of approximately 5 years; the bioventing system is estimated to operate for a period of approximately 30 – 40 years. But for this alternative, which would include a cap over the entire Site, the air exchange necessary for effective operation of the SVE/bioventing system would be limited. The actual operating time of the SVE/bioventing system therefore could be much longer than the estimated times stated. Long-term monitoring would assess effectiveness of continuing remedial systems.

Estimated Cost – moderate. Alternative 7 estimated costs are anticipated to be low relative to the estimated costs of other alternatives.

Conclusion – retained. Alternative 7 is considered potentially technologically and economically feasible due to the moderately difficult degree of implementability and moderate social, environmental, and economic costs. Consequently, Alternative 7 is retained for additional evaluation.

5.6 Retained Alternatives

The following alternatives were retained based on evaluation of effectiveness, implementability and cost:

- Alternative 1
- Alternative 4B
- Alternative 4C
- Alternative 4D
- Alternative 4E
- Alternative 5B
- Alternative 5C
- Alternative 5D
- Alternative 5E
- Alternative 7

The retained alternatives, shown in **Table 5-4**, will undergo detailed evaluation in Section 6.

6. DETAILED EVALUATION OF ALTERNATIVES

6.1 General

This section includes a detailed evaluation of the retained remedial alternatives for the Site. An overview of the criteria used for the detailed evaluation is presented below.

6.2 Detailed Evaluation Criteria

For the detailed evaluation, this Revised FS Report uses as guidance the nine criteria that are identified in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* [USEPA, 1988]. In addition, this Revised FS Report uses three criteria that address key Site-specific issues of importance to alternative evaluation: Consistency with Resolution 92-49, Social Considerations, and Sustainability.

6.2.1 Description of Evaluation Criteria

The first two CERCLA criteria relate directly to findings that must be made in the remedy decision for the Site. These are categorized as threshold criteria that a selected remedy must meet. Each of these criteria is outlined below.

1) **Overall Protection of Human Health and the Environment –** This criterion requires evaluation of how the alternative achieves and maintains protection of human health and the environment. The overall assessment of protectiveness draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Evaluation of the overall protectiveness of an alternative focuses on whether an alternative achieves adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment and institutional controls. This evaluation also considers whether an alternative poses any unacceptable short-term or cross-media impacts.

2) **Compliance with ARARs –** This criterion requires an evaluation of how the alternative complies with identified ARARs and applicable advisories or guidance that are "to be considered." ARARs are generally categorized as action-specific, location-specific, or chemical-specific Federal or state-promulgated requirements. A list of potential Federal and state action-specific, location-specific, or chemical-specific ARARs have been identified for the Site and are included in **Tables 6-1** and **6-3**, respectively.

The following five CERCLA criteria are "balancing" criteria. They represent the primary criteria upon which the detailed evaluation is based and that are used to distinguish among alternatives that meet the threshold requirements above. The alternative that strikes the best balance among these five criteria and that meets the threshold criteria generally is the preferred alternative.

3) **Long-term Effectiveness and Permanence –** Requires evaluation of the long-term effectiveness of the remedial alternative in maintaining protection of human health and the environment following implementation of the alternative.

4) **Reduction of Toxicity, Mobility, and Volume through Treatment –** The assessment against this criterion evaluates the anticipated performance of the treatment technologies that the alternative comprises, and assesses their ability to reduce the toxicity, mobility and volume of impacted materials through the use of treatment.

5) **Short-term Effectiveness –** Requires an assessment of the protection of human health and the environment during construction and implementation of the remedial alternative until RAOs are met. The following factors are addressed as appropriate for each alternative: protection of the community during remedial actions; protection of workers during remedial actions; environmental impacts; and time until remedial response objectives are achieved.

6) **Implementability –** This criterion requires an assessment of the technical and administrative feasibility of an alternative, including the availability of required services and materials to execute the alternative.

7) **Estimated cost –** Requires evaluation of the anticipated capital costs and operation and maintenance (O&M) costs of an alternative. For this Revised FS Report, O&M costs are presented in 2014 dollars without a discount rate being applied.

The following CERCLA criterion in most FS reports is considered following comment on a FS report and on a RAP. However, there is ample public record for an informed evaluation of this criterion to be stated and evaluated in this Revised FS Report.

8) **State Acceptance –** Allows for consideration of preferences or apparent concerns by RWQCB.

The following CERCLA criterion will be considered following comment on this Revised FS Report and on the Revised RAP. It is not further considered in this Revised FS Report:

9) **Community Acceptance** – Allows for consideration of the community's preferences or concerns regarding remedial alternatives. RWQCB will consider the community's preferences or concerns after this Revised FS Report and Revised RAP are reviewed by RWQCB.

Three additional criteria that are important for Site-specific concerns are discussed below:

10) **Consistency with Resolution 92-49 –** The RWQCB letter of January 23, 2014 and the RWQCB letter of April 30, 2014 both place particular emphasis on the provisions of State Water Resources Control Board Resolution 92-49. In part, Resolution 92-49 requires that RWQCB ensure that dischargers are required to clean up and abate the effects of discharges in a manner that promotes attainment of either background water quality or the best water quality which is reasonable if background levels of water quality cannot be restored, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible.

11) **Social Considerations –** For this Revised FS Report, an important evaluation criterion is the potential social impact of the remedial action on the community. Considerations associated with social impact include potential impact on the ability of individual homeowners to enjoy the use of their property (including potential impacts to residents during the remediation project), environmental factors such as traffic, dust and noise, and effects on the integrity and preservation of the neighborhood.

12) **Sustainability** – Sustainability, or green remediation, involves employing technologies and cleanup approaches to reduce a project's environmental footprint. The environmental footprint of a remediation activity exceeds the Site physical boundary because the materials used and the energy consumed create impacts elsewhere. Typically, these offsite impacts have not been fully incorporated into the decision-making process, but their cost ultimately affects society. Sustainability assessments identify potential impacts that may have been discounted, or not included, in traditional assessments. These assessments can illustrate impacts that occur on local, regional, and global scales, including the direct and indirect releases of contaminants; the consumption of raw materials; and the production, collection, and disposal of wastes. Sustainability concepts recognize a holistic assessment in a broader scope and time horizon. In addition to looking beyond project site physical boundaries, sustainability includes the social and economic impacts of remedial decisions. Sustainability integrates many different and sometimes competing factors in planning for the

future and incorporates consideration of factors that may be intangible and unquantifiable.

6.2.2 Discussion of Resolution 92-49 in Evaluation of Alternatives

In its April 30, 3014 comment letter, RWQCB did not concur with the FS Report, in part because analysis presented in the FS Report was deemed to be incomplete with respect to Resolution 92-49 [RWQCB, 2014c]. RWQCB specifically identified areas where more thorough analysis was requested in this Revised FS Report:

- Economic Feasibility
- Nuisance Concerns
- Technological Feasibility, Implementability, and Effectiveness
- Time to Achieve SSCGs

In its comment letter, RWQCB directed that Shell address these areas by evaluating the incremental costs of excavation alternatives in relationship to the incremental reduction in waste concentrations in accordance with Resolution 92-49 [RWQCB, 2014c]. This evaluation, using the points described above, is illustrated in **Table 6-1**, which is discussed below and which will be referenced in the detailed evaluation of alternatives (Section 6.3). Because much of the information in this evaluation is applicable in some form to each of the excavation alternatives (Alternatives 4B – 4E, and 5B – 5E), the information is presented once, then referenced in the evaluation of each alternative.

6.2.2.1 Economic Feasibility

Economic feasibility is an objective balancing of the incremental benefit of attaining further reductions in the concentrations of constituents of concern as compared with the incremental cost of achieving those reductions. The evaluation of economic feasibility includes consideration of current, planned, or future land use; social impacts and economic impacts to the surrounding community including property owners other than the discharger. As per Resolution 92-49, economic feasibility does not refer to the discharger’s ability to finance cleanup. Availability of financial resources should be considered instead in the establishment of reasonable compliance schedules.

In its comment letter, RWQCB asserts that the FS Report does not discuss the incremental benefit of attaining further reductions in the concentration of COCs compared with the incremental cost of achieving those reductions [RWQCB, 2014c].

RWQCB notes that waste concentrations and waste mass increase with depth[9]. RWQCB expects that the incremental costs of excavation with increasing depth are offset by the incremental benefit of reducing concentrations of COCs. RWQCB also notes that the Expert Panel recommended that Shell evaluate excavation alternatives at fewer locations and to greater depths to remove a larger fraction of the TPH than would be removed under Alternative 4B, which was recommended by Shell in the FS Report and in the RAP [RWQCB, 2014c; UCLA Expert Panel, 2014b].

A comparison of the percentage reduction in total mass in the top 10 feet of the Site as opposed to the percentage reduction in total mass present at the Site under various excavation alternatives is shown below:

	Alternative 4B	**Alternative 4C**	**Alternative 4D**	**Alternative 4E**
	Excavation to 3 ft	**Excavation to 5 ft**	**Targeted Excavation from 5 to 10 ft**	**Excavation to 10 ft**
EXCAVATED TPH MASS AS A PERCENTAGE OF MASS IN TOP 10 FEET OF SITE				
Fraction Excavated	4.6%	11.1%	34.5%	46.8%
EXCAVATED TPH MASS AS A PERCENTAGE OF MASS IN TOTAL SITE				
Fraction Excavated	1.2%	2.9%	9.0%	12.3%

Shell estimates that only about 1.2% of the total mass at the Site is removed by excavating from 3 feet bgs (Alternative 4B) to 5 feet bgs (Alternative 4C), and only about 9% of the total mass at the Site is removed by excavating from 5 feet bgs (Alternative 4C) to 10 feet bgs (Alternative 4E).

This distinction is extremely important, because central to the economic feasibility assessment required by Resolution 92-49 is the issue of incremental benefit. Because Resolution 92-49 addresses groundwater protection, it is essential to note that removal of mass in the top 10 feet of the Site (Alternative 4E) leaves about 88% of the mass in place at the Site. The great majority of this mass lies below 10 feet bgs, which is the area of the Site where groundwater impacts, if any, would originate. It is important to recognize that this deeper mass would be addressed by the SVE/bioventing system which is expected to relatively quickly (~5 years) remove the majority of the lighter end (leachable) mass of COCs in the vadose zone soils. Thus, the incremental benefit to

[9] Shell notes that RWQCB generally equates COC mass with COC concentration in its comments, and relies on mass estimates and mass removal to inform its analysis of Resolution 92-49. Although some COC concentration data are available beneath 10 feet bgs, more information exists regarding mass. Shell will equate mass with concentration in its Resolution 92-49 analysis as well.

groundwater protection is limited if additional excavation from 3 feet bgs to 5 feet bgs or to 10 feet bgs is adopted.

Notwithstanding the fact that under any excavation alternative, the great majority of mass would remain in place to be addressed by SVE and bioventing, as directed by RWQCB, **Table 6-1** was prepared to address the issue of incremental benefit in mass reduction vs. incremental cost. The table shows the following:

- Excavation from 3 feet bgs (Alternative 4B) to 5 feet bgs (Alternative 4C) can be achieved at an incremental cost of $26 million, with incremental mass reduction of 280,000 pounds. This equates to an incremental cost per pound of $93.
- Excavation from 5 feet bgs (Alternative 4C) to 5 feet bgs plus targeted deeper excavation to 10 feet bgs (Alternative 4D) can be achieved at an incremental cost of $11 million relative to Alternative 4C, with an incremental mass removal of 1,010,000 pounds. This equates to an incremental cost per pound of $11.
- Excavation from 5 feet bgs plus targeted deeper excavation to 10 feet bgs (Alternative 4D) to 10 feet bgs (Alternative 4E) can be achieved at an incremental cost of $72 million, with an incremental mass removal of 530,000 pounds. This equates to an incremental cost per pound of $136.

These data show, based on this cost comparison, that Alternative 4D is supported over an excavation associated with 4B, 4C, or 4E.

6.2.2.2 Nuisance Concerns

RWQCB asserts that excavation to 3 feet bgs would not be effective in limiting the exposure of residents to waste below 3 feet, because the 3-foot depth excavation alternatives rely upon institutional controls based on the City of Carson Building Code Section 8105 to limit residential exposure below 3 feet [RWQCB, 2014c]. RWQCB commented that the above institutional control may not address protecting residents from gardening or small project excavations that may encounter waste left in place.

Excavating to 2 feet would be protective of normal residential exposure. As previously described by the Expert Panel [Newfields, 2014; USEPA, 2003] has indicated that "Twenty-four (24) inches of clean soil cover is generally considered to be adequate for gardening areas…". Thus, the potential for a resident to contact soils below 3 feet would be very low. In addition, the analysis of the City of Carson Building Code is presented in Section 4.2.1.4 of this Revised FS Report. Local law requires notification and County approval for all excavations deeper than 3 feet, with no exceptions for residential projects/gardening. Shell asserts that this building code provision is fully protective of residents and should limit exposure by residents to soils deeper than 3 feet bgs in most circumstances. However, public information measures such as an informational web site, flyers, etc. may further minimize potential for contact in the residential gardening scenarios. Shell asserts that deeper excavation has some benefits, although negligible, when compared with excavation to 3 feet bgs. It is anticipated that RWQCB would more readily accept deeper excavation, however.

The time to complete the excavation varies in a highly significant way among various excavation depths. As is shown in **Table 6-1**, Alternative 4B (excavation to 3 feet) would require 3.0 years until the excavation and backfill is complete; Alternative 4C (excavation to 5 feet) would require 4.0 years; Alternative 4D (excavation to 5 feet plus targeted excavation to 10 feet) would require 5.1 years; and Alternative 4E (excavation to 10 feet) would require 7.8 years. Combined with the incremental mass reduction associated with the incremental cost described above in Section 6.2.2.1, it is evident that the excavation associated with Alternative 4D can be achieved for 1.1 incremental years of excavation at an incremental cost per pound of $11, but that deeper excavation associated with Alternative 4E can be achieved only at an incremental duration of 3.7 years, and at an incremental cost per pound of $136. This analysis further supports Alternative 4D over 4E.

6.2.2.3 Technological Feasibility, Implementability, and Effectiveness

Technological feasibility is determined by assessing available technologies which have shown to be effective under similar hydrogeologic conditions in reducing the concentration of the constituents of concern. RWQCB states that the FS Report does not adequately consider various excavation technologies which are available to perform excavations to a total depth of 10 feet, and that by limiting the evaluation the FS Report does not consider the effectiveness of the proposed preferred alternative on abating nuisance and protection groundwater quality.

In this Revised FS Report, Alternatives 4D, 4E, 5D, and 5E address the issue of technology available to achieve excavation deeper than 3 feet bgs, in accordance with RWQCB's directive in its comment letter [RWQCB, 2014c]. The presentation in these alternatives recognizes both the feasibility (with challenges) of targeted excavation beneath 3 feet bgs using specialized excavation equipment, and the Site limitations on such excavations as was found in the pilot test report cited above.

RWQCB also addresses time to achieve SSCGs in its comments under the heading of "Technological Feasibility, Implementability, and Effectiveness." The Revised FS Report considers this issue in Section 6.2.2.4 "Time to Achieve SSCGs" below.

6.2.2.4 Time to Achieve SSCGs

In their response to comments on the FS Report, RWQCB indicated that Alternative 4B, the preferred remedy in the FS Report, would achieve remedial goals through SVE/bioventing in a time frame of up to 80 years [RWQCB, 2014c]. RWQCB's estimate is based on the results of the bioventing pilot test [Geosyntec, 2012b], but did not consider the additional impact of the proposed SVE on the remediation time frame. SVE will relatively quickly remediate the more volatile fractions of TPH; thus bioventing will target a smaller mass of residual TPH. This will shorten the time frame for the SVE/bioventing system to achieve RAOs.

Shell has estimated the time frame for the SVE/bioventing system to achieve RAOs. For this estimate, an initial soil concentration of 10,000 mg/kg was assumed (i.e., the same basis presented in the bioventing pilot test report [Geosyntec, 2012b]). Based on the TPH composition (Geosyntec, 2014c) it was assumed that 25 percent of the TPH will be removed by the SVE (i.e., the more volatile fractions of the TPH). Shell estimates that the joint operation of SVE and bioventing will achieve the RAOs within approximately 30 - 40 years.

Remedial actions associated with SVE/bioventing will need to continue in the neighborhood for decades whether excavation takes place to 3 feet bgs, 5 feet bgs, or 10 feet bgs. It is estimated earlier in this Revised FS Report (Section 5.3.3) that SVE will require 5 years post-excavation to achieve its goals, and bioventing will require up to 30 - 40 years to achieve its goals. Because the great majority of the Site mass lies beneath 10 feet bgs (Section 5.2.3), there is a negligible difference among the time frames that would be required to remediate the entire contaminant mass for an excavation to 3 feet, 5 feet, or 10 feet. A small , but not measureable, reduction in the time frame to achieve RAOs may be achieved by optimizing the cyclic operating of the SVE/bioventing system.

With respect to groundwater, source elimination measures including SVE throughout the vadose zone, mobile LNAPL removal, and the Agency's efforts to stop migration of upgradient COCs onto the Site are expected to result in the Site meeting the groundwater SSCGs with the proposed MNA remedy. It should be noted that groundwater already meets, or nearly meets, the SSCGs for Site-related COCs near the downgradient Site boundary. Although excavation of some shallow soils may affect the time for groundwater to meet SSCGs across the Site, this impact is expected to be negligible compared to the other elements of the remedy listed above (SVE, LNAPL removal, stop COCs from migrating onto the Site). A contingency use of oxidant injection in localized areas (i.e., where Site-related COCs exceed 100x MCLs) will be added in the event the MNA remedy is not effective during the monitoring period (5 years following startup of SVE).

The long-term community impacts of continued SVE/bioventing operations, and monitoring and sampling to support other long-term remedy components will be similar for all of the Alternative 4 and 5 options.

6.2.2.5 Conclusion

From the above evaluation of Resolution 92-49, Shell concludes that time to achieve remedial goals cannot be used to justify excavation deeper than 3 feet bgs, but if it is required to remove additional mass than provided in alternative 4B, the evaluation of incremental mass removal vs. incremental cost reduction could be used to justify an excavation to 5 feet bgs with targeted deeper excavation to 10 feet bgs (Alternative 4D). Neither of these points, nor the assessment regarding nuisance, justify an excavation to 10 feet bgs under Alternative 4E.

6.3 Retained Remedial Alternatives – Detailed Evaluation

6.3.1 General

This section includes the detailed evaluation of the retained remedial alternatives presented in **Table 5-4**. Each alternative is evaluated separately according to the criteria listed above. The common elements of the final remedial alternatives are not evaluated, as they are the same for each alternative. A summary of the detailed evaluation of the final remedial alternatives is shown in **Table 6-13**.

6.3.2 Detailed Evaluation of Remedial Alternative 1

6.3.2.1 Overall Protection of Human Health and the Environment

The no action alternative does not effectively mitigate potential future risks associated with the exposure pathways of ingestion, inhalation, or direct contact with Site soils, soil vapor, or leaching to groundwater. It does not provide any means for source zone mass removal and would not be protective of human health and protection of groundwater under the hypothetical future scenario use. It does not meet RAOs. It is included as required by the NCP, and for a baseline against which other alternatives are compared.

6.3.2.2 No Further Evaluation

Because the no action alternative does not meet the threshold requirement of providing overall protection of human health and the environment, no further evaluation of this alternative is performed.

6.3.3 Detailed Evaluation of Alternative 4B

Alt	Existing ICs	Sub-slab Vapor Intrusion Mitigation	Excavate to 3 ft	Excavate Beneath Residential Hardscape	Groundwater MNA and Contingency Groundwater Remediation	Remove Mobile LNAPL	SVE / Bioventing
4B	X	X	X	X	X	X	X

6.3.3.1 Overall Protection of Human Health and the Environment

Alternative 4B would effectively mitigate potential future risks associated with the ingestion, inhalation, or direct contact with Site soils, soil vapor, or groundwater.

Excavation of the upper 3 feet of soil beneath landscaped and residential hardscape areas and replacement with clean soil would mitigate incidental contact with impacted soils. This alternative would therefore meet RAOs for exposure to soils in the upper 3 feet, assuming effectiveness of the existing Institutional Controls (City ordinance).

Vapor intrusion mitigation through sub-slab depressurization (SSD) would mitigate the potential vapor intrusion pathway at properties where sub-slab soil vapor RAOs are not met.

SVE/bioventing would address remaining impacted areas not addressed through excavation beneath landscape and residential hardscape, under concrete foundations of houses, and soils deeper in the vadose zone. The technologies would be used where appropriate, based on Site investigation data, to promote degradation of residual hydrocarbon concentrations that do not meet RAOs. The addition of SVE would decrease the concentrations of VOCs and more volatile fractions of TPH in soil vapor and soil in the areas where it is applied. SVE/bioventing, combined with MNA, would achieve cleanup goals for COCs in the long term. The mass reduction of VOCs and TPH through SVE and bioventing would likely reduce the time required for groundwater restoration.

Mobile LNAPL recovery will continue periodically where LNAPL has accumulated in monitoring wells (MW-3 and MW-12) to the extent technologically and economically feasible, and where a significant reduction in risk to groundwater would result. If mobile LNAPL accumulates in the future in other wells to a measurable thickness, LNAPL recovery will commence from those wells, and if LNAPL accumulates at a thickness of greater than 0.5 foot in other wells, LNAPL will also be periodically recovered from those wells using a dedicated pump. The goal for mobile LNAPL recovery will be an end point of no measurable LNAPL accumulation in monitoring wells at the Site.

Shell proposes to assess the economic and technical feasibility of continued hydraulic recovery of mobile LNAPL using LNAPL transmissivity (Tn) as a criterion. The Interstate Technology and Regulatory Council (ITRC) suggests that hydraulic recovery systems can practically recover LNAPL where the Tn is greater than 0.1 to 0.8 ft2/day and that "Further lowering of Tn is difficult and can be inefficient; that is, it can take very long to marginally reduce Tn without much benefit in terms of reduction of LNAPL mass, migration potential, risk, or longevity" [ITRC, 2009b]. Tn will be assessed at wells exhibiting sufficient LNAPL thickness (at least 0.5 ft) using a baildown/slug test procedure as described by ASTM [2013].

The shallow Bellflower aquitard, in which the uppermost groundwater occurs beneath the Site, and the underlying Gage aquifer are not known sources of drinking water in the Site area, so there is not currently a known groundwater ingestion pathway. As a result of this remedial action, however, groundwater would be protected for designated future beneficial uses such as municipal supply (State Board Resolution No. 68-16). In addition, Site-related COCs in groundwater would be reduced using source reduction (SVE/bioventing, mobile LNAPL reduction) and MNA. The annual MNA program would commence during implementation of the remedy, specifically startup of the SVE/bioventing system. If after five years of semi-annual MNA monitoring the concentrations of Site-related COCs are not stable or decreasing based on statistical analysis, contingency groundwater remediation (oxidant injection) would be implemented in areas of elevated concentrations of Site-related COCs. However, if the concentrations of Site-related COCs are stable or decreasing, the MNA program would continue and would be re-assessed after five additional years of annual groundwater monitoring.

Excavating to 2 feet would be protective of normal residential exposure. As previously described by the Expert Panel [Newfields, 2014; USEPA, 2003] has indicated that "Twenty-four (24) inches of clean soil cover is generally considered to be adequate for gardening areas…". Thus, the potential for a resident to contact soils below 3 feet would be very low. Although this alternative would meet RAOs for exposure to soils in the upper 3 feet, the very low potential for contact with underlying impacted soils below 3 feet bgs would further be limited by the permitting process associated with the City of Carson Building Code Section 8105, which amends the L.A. County Building Code

Section 7003.1. This is an existing institutional control that would limit exposure to soils below 3 feet, and through a notification system that would be developed and established following approval of the RAP.

RWQCB, however, commented that the above institutional control may not address protection of residents from gardening or small project excavations that may encounter waste left in place beneath 3 feet [RWQCB, 2013c]. RWQCB further directed that Shell identify institutional controls that are effective in protecting residents from gardening or small project excavations that may encounter waste left in place. Shell concludes that the existing institutional control, further enhanced with a notification system, is fully protective of human health, and that Alternative 4B is adequately protective, but acknowledges that other alternatives that excavate to a deeper depth may be marginally more protective in the event of inadvertent residential excavation without seeking a City permit.

6.3.3.2 Compliance with ARARs

Alternative 4B would meet the identified ARARs. The ARARs that may be applicable for one or more of the technologies that this alternative comprises are identified in **Tables 6-2** and **6-3**. A separate assessment of this alternative's consistency with State Water Resources Control Board Resolution 92-49 is set forth in Section 6.3.3.8.

6.3.3.3 Long-term Effectiveness and Permanence

The combination of technologies used for Alternative 4B is anticipated to be highly effective at reducing the toxicity, mobility and volume of the COCs in the long-term. It would be a permanent, effective, long-term remedy.

Removal of soils to a depth of 3 feet would remove the impacted soils for which a human exposure pathway potentially is complete, and replace them with clean soils.

SVE/bioventing is anticipated to be effective at the long-term remediation of VOCs and more volatile fractions of TPH. Sub-slab mitigation is an effective measure for vapor intrusion mitigation until no longer needed.

Groundwater goals would be achieved in the long term through the combination of mobile LNAPL removal, source reduction, MNA, and contingency groundwater remediation.

As directed by RWQCB, a long-monitoring program (Sec. 5.3) would include post-excavation soil sampling, soil vapor sampling from probes in the streets, and operational and performance sampling of the SVE/bioventing system and sub-slab depressurization systems. Groundwater monitoring would assess the effectiveness and permanence of this alternative in the long-term.

Overall, the implementability of Alternative 4B would be high.

6.3.3.4 Reduction of Toxicity, Mobility and Volume through Treatment

The following technologies included in this alternative involve treatment of impacted media: offsite treatment/recycling of excavated soils, SVE/bioventing, mobile LNAPL removal, groundwater MNA, and contingency groundwater remediation. These treatment technologies in combination would result in a high degree of reduction of toxicity, mobility, and volume of COCs from the Site.

6.3.3.5 Short-term Effectiveness

The implementation of Alternative 4B would be effective at removing COCs in surface soils to 3 feet and from potential soil vapor migration in the short term. Excavation beneath residential hardscape and landscape would remove impacted soils in the top 3 feet of soil while at the same time temporarily increasing the possibility of negative impacts for the community and for Site workers. During excavation, several mitigation measures would be implemented to minimize negative impacts. Best practices would be utilized so that utilities would be identified and provisions made to protect them in place or remove and reinstall them, efficient equipment would be employed for implementing the remediation, materials would be handled safely, and dust, vapor, and odors would be controlled. Effective odor and vapor control can be achieved during excavation activities by using long-acting vapor suppressant foam when odorous soils are encountered.

As described in the Preliminary Relocation Plan (Appendix D to the Revised RAP), residents of properties where remedial excavations are being conducted would be relocated for the duration of the remedial excavation, backfill, and hardscape restoration operations. Following backfill and utility and hardscape restoration, residents would move back into their homes during landscape restoration and fence/block wall construction, or, at their option, wait to return until after the landscape restoration work is completed. For properties on the perimeter of the tract where excavation work is being conducted, residents of adjacent properties would be offered relocation as necessary.

Sub-slab vapor intrusion mitigation at a limited number of properties where sub-slab soil vapor concentrations do not meet RAOs is a short-term measure to mitigate potential indoor exposure to vapor. Additionally, SVE/bioventing would be effective in the short term at removal of volatile COCs from the subsurface. The degradation of less volatile fractions of TPH through bioventing would take somewhat longer to complete.

Based on the short-term benefits and risks, short-term effectiveness through careful planning and execution is relatively high.

6.3.3.6 Implementability

Implementability of Alternative 4B would be relatively high.

Alternative 4B would be more easily implemented than alternatives that involve deeper excavations because of the lower number of properties affected relative to Alternatives 4D, 4E, 5D, and 5E, decreased volume of soils, the lack of shoring requirements, and the lack of a need to remove and replace utility lines. Alternative 4B would require the excavation of an estimated 202 properties, the same number of properties as Alternatives 4C, 4D, 5B, 5C, and 5D. Alternative 4E and 5E require the excavation of 224 properties.

Alternative 4B would remove a smaller volume of soil than Alternatives 4C, 4D, 4E, 5C, 5D, and 5D. Excavation to 3 feet is more implementable than excavation to 5 or 10 feet because the excavation can be accomplished more easily with potentially no shoring, sloping or setback of the excavation. In addition, some utility lines are likely to be below 3 feet and those that are within the upper 3 feet can be more readily protected than with deeper excavation. The water mains are located at 3 to 3.5 feet, so Alternatives 4B and 5B would present lower risk of damaging the water mains, whereas Alternatives 4C, 4D, 4E, 5C, 5D and 5E may require the capping, excavation and replacement of water mains, as well as gas pipes, and telecommunication lines, which would be disruptive to a very large part of the community. Alternative 4B would pose less of a disturbance to utilities than Alternative 7 because capping the entire Site may require removal or re-routing of utilities to retain access.

The specific details for excavation on a property would be set forth in a property-specific remediation plan (PSRP) to be prepared after approval of the Remedial Design and Implementation Plan (RDIP).

Alternatives 4B, 4C, 4D, and 4E are more difficult to implement than Alternatives 5B, 5C, 5D, 5E, or Alternative 7 because of the additional technical, administrative and design considerations associated with removal and replacement of residential hardscape. Residents would be relocated for a longer period of time to allow for hardscape restoration. There would be greater community disruption due to the greater number of truck trips. Removal of the hardscape significantly increases the amount of waste that must be transported and disposed or recycled. Administrative feasibility is more complex for the Alternative 4 set because the homeowner must agree to hardscape restoration in addition to landscape restoration. Alternative hardscape and landscaping may be considered if requested by the owner and if it does not result in significant schedule or cost impacts.

These added implementability issues make Alternative 4B somewhat more difficult to implement compared with Alternative 5B.

6.3.3.7 Estimated Cost

The cost estimate for Alternative 4B is contained in **Table 6-4** and summarized below. Alternative 4B is less costly than Alternatives 4C, 4D, and 5D, but more costly than Alternatives 5B, 5C and 7. A cost estimate summary follows:

Alternative 4B Remedial Cost Estimate	
Category	**Estimated Cost ($ millions)**
Demolition	**$1.6**
Excavate, Backfill, and Associated Costs	**$38.9**
Other Direct Costs	**$27.1**
Post-Excavation Construction and Long-Term O&M	**$27.8**
TOTAL ESTIMATED COST	**$95**
COST ESTIMATE RANGE (-20%/+30%)	**$76 – $124**

6.3.3.8 State Acceptance

Commonly in FS reports, the criterion of State Acceptance is evaluated following comment on the FS report and on the RAP. However, for the former Kast Property there is ample public record to allow an informed evaluation of RWQCB's position to be stated and evaluated in this Revised FS Report.

When compared against the evaluation of other alternatives, Alternative 4B meets the threshold criteria and provides the best balance of all alternatives against the evaluation criteria (see Section 7 and Section 8). However, in its comments on the FS Report and on the RAP, RWQCB stated that it does not concur with this conclusion, primarily based on the following issues identified by RWQCB regarding an excavation to 3 feet bgs:

- An excavation to 3 ft bgs may not be sufficient to address nuisance caused by the waste at the Site.

- Alternative 4B may not protect residents from exposure during the some types of residential activities such as gardening or small project excavations.
- Alternative 4B would leave a considerable mass of waste in Site soil that could continue to leach to groundwater.
- Alternative 4B does not meet the requirements of Resolution 92-49.

Shell believes that the FS Report and the Revised FS Report have addressed these concerns and demonstrated that Alternative 4B effectively balances these concerns. In addition, the analysis in this Revised FS Report shows that the incremental benefit of deeper excavation beyond that proposed in Alternative 4B is significantly outweighed by the additional duration, impacts, and nuisance to the community. Despite these findings, Shell recognizes the lingering concerns of RWQCB. Therefore, in response to RWQCB's comments and in the interest of State Acceptance, Alternative 4B will not be recommended as the preferred alternative.

6.3.3.9 Consistency with Resolution 92-49

Section 6.2.2 sets forth an assessment of the consistency of excavation of remedial alternatives with Resolution 92-49. Alternative 4B proposes a cleanup of impacted soils on residential properties to a depth of 3 feet. Existing institutional controls, combined with notification procedures and the Surface Containment and Soil Management Plan, provide adequate protection of homeowners against exposure to deeper impacted soils. Other remedial elements of Alternative 4B include additional protections against exposures to Site contaminants, and these other elements also result in RAOs being met for groundwater beneath the Site.

An objective assessment of incremental benefits shows that Alternative 4B meets the threshold criterion of protectiveness of human health and the environment, and it also complies with ARARs. Alternative 4B also results in the safe continued use of the Site for its current residential purpose. It minimizes social impacts, and therefore economic impacts, associated with Site COCs by removing those COCs and achieving the RAOs while preserving the neighborhood and resulting primarily in only short-term inconvenience to the residents.

Despite these findings, Shell recognizes that RWQCB has expressed concerns about the compliance of Alternative 4B with the requirements of Resolution 92-49. In its April 30, 2014 comment letter, RWQCB directed Shell to evaluate incremental costs in relation to incremental reduction in waste concentrations [RWQCB, 2014c]. RWQCB believes that Alternative 4B does not perform as well as deeper excavation alternatives with respect to this evaluation. Therefore, in response to RWQCB's concern, Alternative 4B will not be recommended as the preferred alternative.

6.3.3.10 Social Considerations

Alternative 4B would have a relatively low-to-moderate social impact. An estimated 202 properties would be affected. Excavation and backfill would take approximately 3 weeks per property, plus an additional approximately 3 to 4 weeks for restoration. This is a shorter duration than it would take to implement Alternatives 4C, 4D, 5C and 5D.

The removal and replacement of landscape and hardscape to like conditions may slightly alter the property of the homeowner. During construction, potentially significant air quality, noise, and traffic impacts would be anticipated. Because of the disruption, residents of properties where remedial excavations are being conducted would be relocated for the duration of the remedial excavation, backfill, and hardscape restoration operations. Surrounding areas would be impacted by heavy truck traffic. Similar impacts are anticipated for any of the excavation alternatives (4C, 4D, 5B, 5C, and 5D) but would occur over a lesser duration for Alternative 4B than for any others but Alternative 5B. In addition, based on the results of the excavation pilot testing, the construction impacts associated with traffic, noise, dust, odors can be mitigated. Effective odor and vapor control can be achieved during excavation activities by using long-acting vapor suppressant foam when odorous soils are encountered.

6.3.3.11 Sustainability

Alternative 4B would require the use of excavation equipment and trucks which would create emissions affecting air quality. As the time for remediation and the number of properties and the number of truckloads increases, so would the emissions and effect on air quality. Alternative 4B would have less of an impact on air quality than Alternatives 4C, 4D, 5C and 5D, but it is not as sustainable as Alternatives 5B or 7.

Each alternative requires the disposal of some impacted materials in landfills, along with recycling of most soils. Landfill space is finite and an increased volume of materials being disposed of in landfills reduces the availability of a valuable resource. Alternative 4B would require approximately the same landfill space as Alternatives 4C – 4E, so it is more sustainable in this regard than Alternatives 5B – 5E and 7.

Alternatives 4B, 4C, and 4D create additional waste as opposed to Alternatives 5B, 5C, and 5D because of the removal of residential hardscape.

During construction, removal of landscaping could impact water quality should a storm event occur. Removal of hardscape for Alternatives 4B, 4C and 4D would expose a larger area of soil to potential short-term erosion and water quality issues, although these effects would be mitigated through use of a stormwater pollution protection plan (SWPPP).

6.3.4 Detailed Evaluation of Alternative 4C

Alt	Existing ICs	Sub-slab Vapor Intrusion Mitigation	Excavate to 5 ft	Excavate Beneath Residential Hardscape	Groundwater MNA and Contingency Groundwater Remediation	Remove Mobile LNAPL	SVE / Bioventing
4C	X	X	X	X	X	X	X

6.3.4.1 Overall Protection of Human Health and the Environment

Similar to Alternative 4B, Alternative 4C would effectively mitigate potential future risks associated with the ingestion, inhalation, or direct contact of Site soils, soil vapor, or groundwater.

Excavation of the upper 5 feet of soil and replacement with clean soil would prevent most contact with impacted soils, with the possible exception of excavation for swimming pool installation. The City of Carson Building Code Section 8105, which amends the L.A. County Building Code Section 7003.1, is an existing institutional control that would limit exposure to soils below 3 feet.

Mitigation of vapor intrusion pathways, SVE/bioventing use, mobile LNAPL removal, and groundwater remediation would be the same as for Alternative 4B, and so would be equally protective.

6.3.4.2 Compliance with ARARs

Alternative 4C would meet the identified ARARs. The ARARs that may be applicable for one or more of the technologies that this alternative comprises are identified in **Tables 6-2** and **6-3**. A separate assessment of this alternative's consistency with State Water Resources Control Board Resolution 92-49 is set forth in Section 6.3.4.8.

6.3.4.3 Long-term Effectiveness and Permanence

This alternative would be highly effective in the long-term based on the same considerations as Alternative 4B. Due to the additional volume of soil that would be excavated, the RAOs would be met in soil faster than in Alternative 4B.

6.3.4.4 Reduction of Toxicity, Mobility and Volume through Treatment

The following technologies included in this alternative involve treatment of the media: offsite treatment/recycling of excavated soils, SVE/bioventing, groundwater treatment through contingency groundwater remediation, and mobile LNAPL removal. These treatment technologies would result in the same degree of reduction of toxicity, mobility, and volume through treatment as Alternative 4B.

6.3.4.5 Short-term Effectiveness

In Alternative 4C, excavating an additional 2 feet of soil relative to Alternative 4B would result in a longer period of exposure to potentially impacted soil, and therefore would pose potentially greater negative impacts to the community and workers than for Alternative 4B. The short-term effectiveness of sub-slab vapor intrusion mitigation, SVE/bioventing, and mobile LNAPL removal and contingency groundwater remediation would be similar to Alternative 4B.

Based on the short-term benefits and risks, short-term effectiveness through careful planning and execution is moderate.

6.3.4.6 Implementability

Alternative 4C is less implementable than Alternatives 4B, 5B, and 5C, and more implementable than 4D, 4E, 5D, and 5E because of the volume of soils, the number of properties affected, the necessity for shoring or slot trenching, the need to protect water mains, and the potential impacts on utility lines. Alternative 4C would require the excavation of 202 properties. This is the same number of properties as Alternatives 4B, 5B, and 5C. Alternative 4E and 5E require the excavation of 224 properties.

Alternative 4C requires a smaller volume of soil removed than Alternatives 4D, 4E, 5D, and 5E, but a larger volume than Alternatives 4B, 5B and 5C. Deeper excavation increases the soil excavated and recycled or disposed, and the amount of clean soil brought back to the Site. Alternative 4C has increased permitting requirements from Alternatives 4B and 5B since shoring or slot trenching would be required by OSHA for trenching at or below 5 feet in depth, and greater setbacks from structures would be required for stability.

Excavation to 5 feet for Alternative 4C has low implementability because utility lines would be encountered at this depth. Alternative 4C requires the protection of water mains and avoiding removal of some impacted soil around them, addressing gas pipes, and telecommunication lines. Alternative 4C is less implementable than Alternatives 4B and 5B, for which utility impacts would be more readily addressed due to the lesser depth of excavation.

Alternative 4C would rely upon existing institutional controls to prevent contact with soils below the depth of excavation.

The set of Alternatives 4B, 4C, 4D, and 4E is more difficult to implement than the set of Alternatives 5B, 5C, 5D, and 5E or Alternative 7 because of the additional technical, administrative and design considerations associated with removal and replacement of residential hardscape. Removal of the hardscape increases the amount of waste that must be transported and disposed or recycled. Administrative feasibility is more complex for the Alternative 4 set because the homeowner must agree to hardscape and landscape restoration. Alternative hardscape and landscaping may be considered if requested by the owner and if it does not result in significant schedule or cost impacts.

These added implementability issues make Alternative 4C more difficult to implement than Alternatives 4B, 5B, and 5C.

6.3.4.7 Estimated Cost

The cost estimate for Alternative 4C is contained in **Table 6-5**. A cost estimate summary follows:

Alternative 4C Remedial Cost Estimate	
Category	**Estimated Cost ($ millions)**
Demolition	**$1.6**
Excavate, Backfill, and Associated Costs	**$55.9**
Other Direct Costs	**$35.9**
Post-Excavation Construction and Long-Term O&M	**$28.0**
TOTAL ESTIMATED COST	**$121**
COST ESTIMATE RANGE (-20%/+30%)	**$97 – $157**

6.3.4.8 State Acceptance

Commonly in FS reports, the criterion of State Acceptance is evaluated following comment on the FS report and on the RAP. However, for the former Kast Property there is ample public record to allow an informed evaluation of RWQCB’s position to be stated and evaluated in this Revised FS Report.

Based on RWQCB's April 30, 2014 comment letter and subsequent discussions, Shell believes that excavation to 5 feet would be more preferable to RWQCB than excavation to 2 or 3 feet. Shell has included an assessment of mass removal against incremental cost of achieving this mass removal (See **Table 6-1**). It is anticipated that Alternative 4C may be more acceptable to RWQCB than Alternative 1, 4A or 4B for the following reasons:

- An excavation to 5 ft bgs would be sufficient to address RWQCB concerns regarding potential nuisance caused by the waste at the Site.
- Alternative 4C would protect residents from exposure during some types of residential activities such as gardening or small project excavations.
- Alternative 4C would remove a larger mass of waste in Site soil than would be removed under Alternative 4B.
- It is logical to assume that the larger amount of mass removal under Alternative 4C would result in some incremental (but not measureable) reduction of operating time of the SVE/bioventing system, and therefore the time required to achieve groundwater cleanup goals, when compared with Alternative 4B.

6.3.4.9 Consistency with Resolution 92-49

Section 6.2.2 sets forth an assessment of the consistency of excavation of remedial alternatives with Resolution 92-49. Alternative 4B proposes a cleanup of impacted soils on residential properties to a depth of 3 feet. Existing institutional controls, combined with notification procedures and the Surface Containment and Soil Management Plan, provide adequate protection of homeowners against exposure to deeper impacted soils. Other remedial elements of Alternative 4B include additional protections against exposures to Site contaminants, and these other elements also result in RAOs being met for groundwater beneath the Site.

An objective assessment of incremental benefits shows that Alternative 4B meets the threshold criterion of protectiveness of human health and the environment, and it also complies with ARARs. Alternative 4B also results in the safe continued use of the Site for its current residential purpose. It minimizes social impacts, and therefore economic impacts, associated with Site COCs by removing those COCs and achieving the RAOs while preserving the neighborhood and resulting primarily in only short-term inconvenience to the residents.

Despite these findings, Shell recognizes that RWQCB has expressed concerns about the compliance of Alternative 4B with the requirements of Resolution 92-49. In its April

30, 2014 comment letter, RWQCB directed Shell to evaluate incremental costs in relation to incremental reduction in waste concentrations [RWQCB, 2014c]. Shell has done so, and has included an assessment of mass removal against incremental cost of achieving this mass removal (See **Table 6-1**). It is anticipated that RWQCB may conclude that Alternative 4C performs better than Alternatives 1, 4A, or 4B with respect to this evaluation. Therefore, in response to RWQCB's concern, Alternative 4C is deemed more acceptable to RWQCB than Alternative 1, 4A or 4B.

6.3.4.10 Social Considerations

The range of social impacts and disruption for Alternative 4C would be similar as for Alternative 4B, but the duration of the alternative would be about a year longer, so that Alternative 4C would have a moderately high social impact. Residents would be relocated for a longer period of time than in Alternative 4B due to the additional time and difficulty involved with the deeper excavations.

6.3.4.11 Sustainability

Alternative 4C has the same sustainability issues as discussed for 4B. Alternative 4C would create more greenhouse gas emissions from equipment since more soil would need to be transported and excavated, and there would be greater greenhouse gas emissions associated with the larger volume of impacted soil excavated. Alternative 4C would require approximately the same landfill space as Alternatives 4B, 4D and 4E, so it is more sustainable in this regard than Alternatives 5B – 5E and 7. There may also be increased waste due to excavating and replacing utilities.

6.3.5 Detailed Evaluation of Alternative 4D

Alt	Existing ICs	Sub-slab Vapor Intrusion Mitigation	Excavate to 5 ft with Additional Targeted Excavation to 10 ft	Excavate Beneath Residential Hardscape	Groundwater MNA and Contingency Groundwater Remediation	Remove Mobile LNAPL	SVE / Bioventing
4D	X	X	X	X	X	X	X

6.3.5.1 Overall Protection of Human Health and the Environment

Similar to Alternative 4C, Alternative 4D would effectively mitigate potential future risks associated with the ingestion, inhalation, or direct contact of Site soils, soil vapor, or groundwater.

Initial excavation of the upper 5 feet of soil and replacement with clean soil would prevent most contact with impacted soils. Additional targeted excavation of soil from 5 feet bgs to 10 feet bgs at localized areas and replacement with controlled low strength material (CLSM) and clean soil would prevent contact with the most impacted soils (i.e., those soils above 10 times the TPH SSCGs) and from lesser impacted soils (i.e., those remaining in place from > 5 feet bgs to ≤ 10 feet bgs), with the possible exception of excavation for swimming pool installation or for extensive construction (i.e., for soils > 10 feet bgs). However, due to setback and shoring requirements, and also due to the presence of the transite water mains, some impacted soil beneath landscaping and hardscape in the upper 10 feet would be left in place. The City of Carson Building Code Section 8105, which amends the L.A. County Building Code Section 7003.1, is an existing institutional control that would limit exposure to soils below 3 feet.

Mitigation of vapor intrusion pathways, SVE/bioventing use, mobile LNAPL removal, and groundwater remediation would be the same as for Alternative 4B, and so would be equally protective.

6.3.5.2 Compliance with ARARs

Alternative 4D would meet the identified ARARs. The ARARs that may be applicable for one or more of the technologies that this alternative comprises are identified in **Tables 6-2** and **6-3**. A separate assessment of this alternative's consistency with State Water Resources Control Board Resolution 92-49 is set forth in Section 6.3.5.8.

6.3.5.3 Long-term Effectiveness and Permanence

Alternative 4D would be highly effective in the long-term based on the same considerations as Alternative 4B. Due to the additional volume of soil that would be excavated, the RAOs would be met in soil faster than in Alternative 4B and 4C.

6.3.5.4 Reduction of Toxicity, Mobility and Volume through Treatment

The following technologies involved in this alternative involve treatment of the media: offsite treatment/recycling of excavated soils, SVE/bioventing, groundwater treatment through contingency groundwater remediation, and mobile LNAPL removal. These treatment technologies would result in a high degree of reduction of toxicity, mobility, and volume from the Site.

6.3.5.5 Short-term Effectiveness

For Alternative 4D, excavating an additional 5 feet of depth relative to Alternative 4C (in targeted areas on selected properties) would result in significantly more days when impacted soil would be exposed, much more disruption of the community, and much longer homeowner relocation, and therefore pose much greater negative impacts to the community and workers than for Alternative 4C. The short-term effectiveness of sub-slab vapor intrusion mitigation, SVE/bioventing, and mobile LNAPL removal and contingency groundwater remediation of groundwater would be similar to Alternative 4B and 4C. The same number of houses would be affected by excavation (202) for Alternative 4D as for Alternatives 4B and 4C, but 82 of those houses would receive targeted excavation to 10 feet bgs. Because there would be additional very significant negative impacts with only moderate additional benefits, short-term effectiveness is low.

6.3.5.6 Implementability

Alternative 4D is less implementable than Alternatives 4B, 4C, 5B, 5C and 5D, and more implementable than 4E and 5E because of the volume of soils, the number of properties affected, the necessity for shoring or slot trenching, the greater time required to excavate using auger equipment, the need to protect water mains, and the potential impacts on utility lines. Alternative 4D would require the excavation of 202 properties. This is the same number of properties as Alternatives 4B, 4C, 5B, 5C, and 5D. Alternative 4E and 5E require the excavation of 224 properties.

Alternative 4D requires removal of a smaller volume of soil than Alternatives 4E and 5E, but a larger volume than Alternatives 4B, 4C, 5B and 5C. Deeper excavation increases the soil excavated and recycled or disposed, and the amount of clean soil and CLSM (2-sack slurry) brought back to the Site. Like Alternative 4C and 5C, Alternative 4D has increased complexity compared with Alternatives 4B and 5B because shoring or slot trenching would be required by OSHA for trenching at or below 5 feet in depth, and greater setbacks from structures or auger excavation would be required for stability, and concrete trucks and pumpers would be needed for placement of CLSM in auger-excavated boreholes or the lower part of slot trenches.

The initial excavation to 5 feet for Alternative 4D has low implementability because utility lines would be encountered at this depth. Alternative 4D requires the protection of water mains and avoiding removal of some impacted soil around them, addressing gas pipes, and telecommunication lines. Alternative 4D is less implementable than Alternatives 4B and 5B, for which utility impacts would be more readily addressed due to the lesser depth of excavation. Additional targeted excavation to 10 feet may require larger setbacks to protect structures than shallower excavations, resulting in a significantly smaller area of each property being available for excavation. It requires a larger excavator to reach the depth of 10 feet. In addition, the very significant shoring, setback and other protections required would limit the ability to reach a depth of 10 feet in some targeted areas. These difficulties could be mitigated to some degree with the use of specialized construction equipment such as a track-mounted limited access auger drilling rig, with the tradeoff being significant additional remediation durations and costs.

Where it is possible to excavate to 10 feet in back yards, a further complication arises because of the presence of overhead utility lines. Worker protection from electrocution hazard due to the excavator encountering overhead power lines likely would require removal of power lines during excavation and restoration, which would have further impacts to the resident's property and possibly to other properties. Alternative 4D may require removal and replacement of utility lines on each property, and either protection of water mains gas pipes, sewer laterals, and telecommunication lines in place, which would leave impacted soil in place, or manual excavation around pipes. Additionally, appropriate setbacks and maximum excavation depths adjacent to power poles located in the rear of back yards would need to be established with Southern California Edison, which would limit areas that can be excavated to 10 feet. Either approach would be very difficult. Accordingly Alternative 4D is less implementable than Alternatives 4B and 5B for which utility work is more manageable.

Alternative 4D would rely upon existing institutional controls to prevent contact with soils below the depth of excavation.

The series of Alternatives 4B, 4C, 4D, and 4E is more difficult to implement than the series of Alternatives 5B, 5C, 5D, and 5E, or Alternative 7 because of the additional technical, administrative and design considerations associated with removal and replacement of residential hardscape. Removal of the hardscape increases the amount of waste that must be transported and disposed or recycled. Administrative feasibility is more complex for the Alternative 4 series because the homeowner must agree to hardscape and landscape restoration. Alternative hardscape and landscaping may be considered if requested by the owner and if it does not result in significant schedule or cost impacts. Alternative 4D also presents additional safety hazards than those associated with excavations to depths of 5 feet or less.

These added implementability issues make Alternative 4D more difficult to implement than Alternatives 4B, 4C, 5B, 5C, and 5D.

6.3.5.7 Estimated Cost

The cost estimate for Alternative 4D is contained in **Table 6-6**. Alternative 4D has a high cost. It is the third highest cost alternative of the final remedial alternatives. A cost summary follows:

Alternative 4D Remedial Cost Estimate	
Category	**Estimated Cost ($ millions)**
Demolition	**$1.6**
Excavate, Backfill, and Associated Costs	**$60.2**
Other Direct Costs	**$42.3**
Post-Excavation Construction and Long-Term O&M	**$28.3**
TOTAL ESTIMATED COST	**$132**
COST ESTIMATE RANGE (-20%/+30%)	**$106 – $172**

6.3.5.8 State Acceptance

Commonly in FS reports, the criterion of State Acceptance is evaluated following comment on the FS report and on the RAP. However, for the former Kast Property there is ample public record to allow an informed evaluation of RWQCB's position to be stated and evaluated in this Revised FS Report.

Based on RWQCB's April 30, 2014 comment letter and subsequent discussions, Shell believes that excavation to 5 feet would be more preferable to RWQCB than excavation to 2 or 3 feet, however RWQCB has also has asked Shell to also explore the feasibility of technologies to excavate to 10 feet where practicable. Shell has done so, and has included an assessment of mass removal against incremental cost of achieving this mass removal (See **Table 6-1**). It is anticipated that Alternative 4D may be more acceptable to RWQCB than Alternative 1, 4A, 4B, or 4C for the following reasons:

- An excavation to 5 ft bgs with targeted excavation to 10 ft bgs would be sufficient to address RWQCB concerns regarding potential nuisance caused by the waste at the Site.
- Alternative 4D would protect residents from exposure during some types of residential activities such as gardening or small project excavations.
- Alternative 4D would remove an even larger mass of waste in Site soil than would be removed under Alternatives 4B or 4C.
- It is logical to assume that this even larger amount of mass removal under Alternative 4D would result in some incremental (but non measureable) reduction of operating time of the SVE/bioventing system, and therefore the time required to achieve groundwater cleanup goals, when compared with Alternative 4B or 4C.

6.3.5.9 Consistency with Resolution 92-49

Section 6.2.2 sets forth an assessment of the consistency of excavation of remedial alternatives with Resolution 92-49. Alternative 4B proposes a cleanup of impacted soils on residential properties to a depth of 3 feet. Existing institutional controls, combined with notification procedures and the Surface Containment and Soil Management Plan, provide adequate protection of homeowners against exposure to deeper impacted soils. Other remedial elements of Alternative 4B include additional protections against exposures to Site contaminants, and these other elements also result in RAOs being met for groundwater beneath the Site.

An objective assessment of incremental benefits shows that Alternative 4B meets the threshold criterion of protectiveness of human health and the environment, and it also complies with ARARs. Alternative 4B also results in the safe continued use of the Site for its current residential purpose. It minimizes social impacts, and therefore economic impacts, associated with Site COCs by removing those COCs and achieving the RAOs while preserving the neighborhood and resulting primarily in only short-term inconvenience to the residents.

Despite these findings, Shell recognizes that RWQCB has expressed concerns about the compliance of Alternative 4B with the requirements of Resolution 92-49. In its April 30, 2014 comment letter, RWQCB directed Shell to evaluate incremental costs in relation to incremental reduction in waste concentrations [RWQCB, 2014c]. Shell has done so, and has included an assessment of mass removal against incremental cost of achieving this mass removal (See **Table 6-1**). It is anticipated that RWQCB may conclude that Alternative 4D performs better than Alternatives 1, 4A, 4B, or 4C with respect to this evaluation. Therefore, in response to RWQCB's concern, Alternative 4D is deemed more acceptable to RWQCB than Alternative 1, 4A or 4B.

6.3.5.10 Social Considerations

Alternative 4D would have a high level of social impact. Alternative 4D has the same impacts that were discussed for Alternative 4B and 4C. Alternative 4D has an added social impact because the excavation and soil replacement would take longer than Alternatives 4B or 4C because of additional soil excavation, the added time associated with auger excavation, and utilities interruption and restoration. There would be increased truck traffic from Alternative 4D due to more soil being removed than for Alternative 4B, 4C, 5B, 5C, and 5D, and due to the extensive lengthy disruption of the community.

6.3.5.11 Sustainability

Alternative 4D has more significant negative sustainability effects than discussed for 4B and 4C. Alternative 4D would create more greenhouse gas emissions from equipment since more soil would need to be transported and excavated. Alternative 4D would release more methane to the atmosphere. While fire and explosion hazards have not been identified at any residence due to methane concentrations from degradation of hydrocarbons in soil vapor, this would be considered a greenhouse gas emission and therefore a detrimental impact to air quality. The amount of greenhouse gases released would be far less with excavation to 3 feet under Alternative 4B than to 5 feet or to 10 feet, even if just in targeted areas. Alternative 4D would require approximately the same landfill space as Alternatives 4B, 4C and 4E, so it is more sustainable in this regard than Alternatives 5B – 5E and 7. There may also be increased waste due to excavating and replacing utilities.

6.3.6 Detailed Evaluation of Alternative 4E

Alt	Existing ICs	Sub-slab Vapor Intrusion Mitigation	Excavate to 10 ft	Excavate Beneath Residential Hardscape	Groundwater MNA and Contingency Groundwater Remediation	Remove Mobile LNAPL	SVE / Bioventing
4E	X	X	X	X	X	X	X

6.3.6.1 Overall Protection of Human Health and the Environment

Similar to Alternatives 4B, 4C and 4D, Alternative 4E would effectively mitigate potential future risks associated with the ingestion, inhalation, or direct contact of Site soils, soil vapor, or groundwater.

Excavation of the upper 10 feet of soil and replacement with replacement with controlled low strength material (CLSM) and clean soil would prevent contact with the most impacted soils (i.e., those soils above 10 times the TPH SSCGs) and from lesser impacted soils (i.e., those remaining in place from > 5 feet bgs to ≤ 10 feet bgs), with the possible exception of excavation for swimming pool installation or for extensive construction (i.e., for soils > 10 feet bgs. However, due to setback and shoring requirements, and also due to the presence of the transite water mains, some impacted soil beneath landscaping and hardscape in the upper 10 feet would be left in place. The City of Carson Building Code Section 8105, which amends the L.A. County Building Code Section 7003.1, is an existing institutional control that would limit exposure to soils below 3 feet. Mitigation of vapor intrusion pathways and groundwater remediation would be the same as for Alternative 4B, and so would be equally protective.

6.3.6.2 Compliance with ARARs

Alternative 4E would meet the identified ARARs. The ARARs that may be applicable for one or more of the technologies that comprise this alternative are identified in **Tables 6-2** and **6-3**. A separate assessment of this alternative's consistency with State Water Resources Control Board Resolution 92-49 is set forth in Section 6.3.5.8.

6.3.6.3 Long-term Effectiveness and Permanence

Alternative 4E would be highly effective in the long-term based on the same considerations as Alternatives 4B, 4C and 4D. Due to the additional volume of soil that would be excavated, the RAOs would be met in soil faster than in Alternatives 4B, 4C and 4D.

6.3.6.4 Reduction of Toxicity, Mobility and Volume through Treatment

The following technologies involved in this alternative involve treatment of the media: offsite treatment/recycling of excavated soils, SVE/bioventing, groundwater treatment through contingency groundwater remediation, and mobile LNAPL removal. These treatment technologies would result in a high degree of reduction of toxicity, mobility, and volume from the Site.

6.3.6.5 Short-term Effectiveness

For Alternative 4E, excavating an additional 5 feet of depth relative to Alternative 4C, and available soil to 10 feet relative to Alternative 4D would result in significantly more days when impacted soil would be exposed, much more disruption of the community, and therefore pose much greater negative impacts to the community and workers than for Alternatives 4C and 4D. The short-term effectiveness of sub-slab vapor intrusion mitigation, SVE/bioventing, and mobile LNAPL removal and contingency groundwater remediation of groundwater would be similar to Alternatives 4B, 4C and 4D. A larger number of houses would be affected by excavation: 224 for Alternative 4D as compared with 202 for Alternatives 4B, 4C and 4D. Because there would be additional very significant negative impacts without significant additional benefits, short-term effectiveness is very low.

6.3.6.6 Implementability

Excavation to 10 feet would require larger setbacks and more shoring to protect structures than shallower excavations, resulting in less area of each property being available for excavation. Also, excavation to 10 feet would require extensive shoring or slot trenching to protect structures. For the pilot test excavation, the County Department of Public Works required that excavation slots be backfilled the same day as they were excavated. For full-scale implementation, there may not be sufficient time in a given work day to excavate a slot, load and transport excavated soils, particularly for back yards which would require transferring soils to the street for loading, and backfill the slot. This onerous constraint would further reduce the feasibility of Alternative 4E.

When compared with Alternatives 4B, 4C, 4D, 5B, 5C and 5D, Alternative 4E involves the greatest volume of soils, the greatest number of properties affected, the longest period of remediation per property, the greatest amount of shoring, increased equipment requirements, and the greatest difficulty posed by the presence of utility lines. Alternative 4E would require the excavation of 224 properties, whereas Alternatives 4B, 4C, and 4D require the excavation of 202 properties.

Alternative 4E requires the largest volume of soil to be excavated and disposed and the largest amount of clean soil brought back the Site. Alternative 4E has increased permitting requirements compared with Alternatives 4B, 4C, 5B, and 5C since shoring or slot trenching is required by OSHA for trenching at or below 5 feet in depth and greater setbacks from structures would be required for stability. Alternative 4E would also require a geotechnical investigation for every property as part of the remedy design phase, including drilling of soil borings to 20 feet bgs at all or most properties in order to obtain the data needed to support design and permitting.

Where it is possible to excavate to 10 feet in back yards, a further complication arises because of the presence of overhead utility lines. Worker protection from electrocution hazard due to the excavator encountering overhead power lines likely would require removal of power lines during excavation and restoration, which would have further impacts to the resident's property and possibly to other properties. Alternative 4E would require removal and replacement or protection in place of utility lines on each property, including water mains, sewer laterals, gas pipes, and telecommunication lines, which would leave impacted soil in place, or manual excavation around pipes. Either approach would be very difficult. Accordingly Alternative 4E is less implementable than Alternatives 4B, 4C, 5B and 5C for which utility work is more manageable.

Alternative 4E would rely on existing institutional controls to prevent contact with significant impacted soils which would remain below 3 feet bgs, due to setback requirements and potential utility protection.

6.3.6.7 Estimated Cost

The cost estimate for Alternative 4E is contained in **Table 6-7**. Alternative 4E has an extraordinarily high cost. It is the highest cost alternative of the final remedial alternatives. A cost summary follows:

Alternative 4E Remedial Cost Estimate	
Category	**Estimated Cost ($ millions)**
Demolition	**$1.8**
Excavate, Backfill, and Associated Costs	**$111.8**
Other Direct Costs	**$60.9**
Post-Excavation Construction and Long-Term O&M	**$29.0**
TOTAL ESTIMATED COST	**$204**
COST ESTIMATE RANGE (-20%/+30%)	**$163 – $265**

6.3.6.8 State Acceptance

Commonly in FS reports, the criterion of State Acceptance is evaluated following comment on the FS report and on the RAP. However, for the former Kast Property there is ample public record to allow an informed evaluation of RWQCB's position to be stated and evaluated in this Revised FS Report.

Based on RWQCB's April 30, 2014 comment letter and subsequent discussions, Shell believes that excavation to 5 feet would be more preferable to RWQCB than excavation to 2 or 3 feet, however RWQCB also has asked Shell to also explore feasibility of technologies to excavate the entire Site to 10 feet. Shell has done so, and finds that although it is logical to assume that the even larger amount of mass removal would, in some incremental (but not measureable) way, result in further reduction of operating time of the SVE/bioventing system and therefore the time required to achieve groundwater cleanup goals, when compared with Alternatives 4B, 4C, or 4D, such reduction in time likely would be negligible and would be outweighed by the additional nuisance associated with the lengthy excavation time frame associated with Alternative 4E, and the much higher incremental cost of removing this added mass (see **Table 6-1**).

Shell therefore finds no basis to conclude that Alternative 4E would be better than Alternatives 4C or 4D for the following reasons:

- An excavation to 10 ft bgs would be extremely difficult to implement and would not further reduce nuisance caused by the waste at the Site, when compared with Alternatives 4C or 4D.
- Alternative 4E would not further protect residents from exposure during some types of residential activities such as gardening or small project excavations when compared with Alternatives 4C or 4D.
- Although Alternative 4E would remove an even larger mass of waste in Site soil than would be removed under Alternatives 4C or 4D, such removal would be achieved only at an economically infeasible cos.
- Alternative 4E would require deeper excavations at an additional 142 residences that would not have such deeper excavations under Alternative 4D, thus increasing the time for remediation at these homes.
- Alternative 4E likely would create additional disruption to the community when compared with Alternatives 4B, 4C, or 4D due to the much longer timeframe associated with excavation.
- Because the marginal benefit from removing the additional mass in Alternative 4E is greatly outweighed by the additional cost and disruption to the homeowners and the community, Alternative 4E does not best meet the requirements of Resolution 92-49.

6.3.6.9 Consistency with Resolution 92-49

Section 6.2.2 sets forth an assessment of the consistency of excavation of remedial alternatives with Resolution 92-49.

Alternative 4B proposes a cleanup of impacted soils on residential properties to a depth of 3 feet. Existing institutional controls, combined with notification procedures and the Surface Containment and Soil Management Plan, provide adequate protection of homeowners against exposure to deeper impacted soils. Other remedial elements of Alternative 4B include additional protections against exposures to Site contaminants, and these other elements also result in RAOs being met for groundwater beneath the Site.

An objective assessment of incremental benefits shows that Alternative 4B meets the threshold criterion of protectiveness of human health and the environment, and it also complies with ARARs. Alternative 4B also results in the safe continued use of the Site for its current residential purpose. It minimizes social impacts, and therefore economic impacts, associated with Site COCs by removing those COCs and achieving the RAOs while preserving the neighborhood and resulting primarily in only short-term inconvenience to the residents.

Despite these findings, Shell recognizes that RWQCB has expressed concerns about the compliance of Alternative 4B with the requirements of Resolution 92-49. In its April 30, 2014 comment letter, RWQCB directed Shell to evaluate incremental costs in relation to incremental reduction in waste concentrations [RWQCB, 2014c]. Shell has done so, and has included an assessment of mass removal against incremental cost of achieving this mass removal (See **Table 6-1**). Shell believes that this assessment shows clearly that Alternative 4E does not perform as well as Alternatives 4B, 4C, or 4D with respect to this evaluation. For many of the same reasons provided under the evaluation criterion of State Acceptance, Alternative 4E would not best meet the requirements of Resolution 92-49.

6.3.6.10 Social Considerations

Alternative 4E has the same impacts that were discussed for 4B, 4C and 4D. Alternative 4E has an added social impact because the excavation and soil replacement, were it implementable, would take many days longer per house, and years longer overall, than Alternatives 4B, 4C or 4D because of additional soil, shoring, and work with utilities. There would be increased truck traffic from Alternative 4E due to more soil and hardscape being removed from a greater number of properties than for any other alternative, and due to the extensive lengthy disruption of the community.

6.3.6.11 Sustainability

Alternative 4E has more significant negative sustainability effects than discussed for 4B, 4C or 4D. Alternative 4E would create more greenhouse gas emissions from equipment since more soil would need to be transported and excavated. Alternative 4E would release more methane to the atmosphere. While fire and explosion hazards have not been identified at any residence due to methane concentrations from degradation of hydrocarbons in soil vapor, methane would be considered a greenhouse gas emission and therefore a detrimental impact to air quality. The amount of greenhouse gases released would be far less with excavation to 3 feet under Alternative 4B than excavation to 5 feet or especially to 10 feet. Each alternative requires the treatment and recycling or disposal of some impacted soil in landfills, along with some recycled materials. Landfill space and recycling capacity are finite and an increased volume of soil being disposed of in landfills reduces the availability of these valuable resources.

Alternative 4E would require approximately the same landfill space as Alternatives 4B – 4D, so it is more sustainable in this regard than Alternatives 5B – 5E and 7.

6.3.7 Detailed Evaluation of Alternative 5B

Alt	Existing ICs	Sub-slab Vapor Intrusion Mitigation	Excavate to 3 ft	Excavate Beneath Residential Hardscape	Groundwater MNA and Contingency Groundwater Remediation	Remove Mobile LNAPL	SVE / Bioventing
5B	X	X	X	N/A	X	X	X

6.3.7.1 Overall Protection of Human Health and the Environment

Alternative 5B would effectively mitigate potential future risks associated with the ingestion, inhalation, or direct contact of Site soils, soil vapor, or groundwater, except that future risks for soil exposure beneath residential hardscape would not be mitigated. Excavation of the upper 3 feet of soil in landscaped areas and replacement with clean soil would mitigate incidental contact with impacted soils. Alternative 4B differs from Alternative 5B in the approach to residential hardscape. In Alternative 4B, residential hardscape is removed and impacted soils are excavated to a depth of 3 feet prior to backfilling the excavation and replacing the hardscape. In Alternative 5B, no removal of residential hardscape occurs and no excavation is conducted beneath residential hardscape. The City of Carson does not require that homeowners obtain a permit or notify the City prior to removing residential hardscape from their property. Because of the lack of a permitting or notification requirement, Alternative 5B, which does not include excavation of impacted soils beneath residential hardscape, is not expected to be as protective as Alternative 4B which includes excavation beneath residential hardscape to 3 feet. For Alternative 5B to be protective, an additional LUC or a notification system would be required to ensure notification to Shell for removal of residential hardscape or digging beneath residential hardscape, but it would not be effective absent homeowner agreement and cooperation.

6.3.7.2 Compliance with ARARs

Alternative 5B would meet the identified ARARs. The ARARs that may be applicable for one or more of the technologies that this alternative comprises are identified in **Tables 6-2** and **6-3**. A separate assessment of this alternative's consistency with State Water Resources Control Board Resolution 92-49 is set forth in Section 6.3.6.8.

6.3.7.3 Long-term Effectiveness and Permanence

Without an additional LUC or a notification system required to ensure notification to Shell for removal of residential hardscape or digging beneath landscape, Alternative 5B would not be as effective or permanent in the long term as Alternative 4B.

6.3.7.4 Reduction of Toxicity, Mobility and Volume through Treatment

The following technologies included in this alternative involve treatment of the media: offsite treatment/recycling of excavated soils, SVE/bioventing, groundwater treatment through contingency groundwater remediation, and mobile LNAPL removal. These treatment technologies would result in a high degree of reduction of toxicity, mobility, and volume from the Site, similar to Alternatives 4B, 4C, 4D, and 4E.

6.3.7.5 Short-term Effectiveness

Alternative 5B would have somewhat fewer short-term effectiveness considerations relative to Alternative 4B (e.g., less material to remove from the Site), so the short-term effectiveness is relatively high.

6.3.7.6 Implementability

Implementability of Alternative 5B is relatively high.

Alternative 5B would be more easily implemented than alternatives that excavate deeper because of the decreased volume of soils, number of properties affected, and lack of shoring or setbacks to protect houses or utility lines. It would also be easier to implement than Alternative 4B, which would require excavation of residential hardscape. Alternative 5B would require the excavation of 202 properties. This is the same number of properties as Alternatives 4B, 4C, 4D, and 5C, and 5D. Alternatives 4E and 5E require the excavation of 224 properties.

Other implementability considerations are similar to Alternative 4B, except that no residential hardscape is removed in Alternative 5B.

6.3.7.7 Estimated Cost

The cost estimate for Alternative 5B is contained in **Table 6-8**. Alternative 5B is moderately costly, but it is the least expensive of the excavation alternatives (4B-4E and 5B-5E). A cost estimate summary follows:

Alternative 5B Remedial Cost Estimate	
Category	**Estimated Cost ($ millions)**
Demolition	**---**
Excavate, Backfill, and Associated Costs	**$26.0**
Other Direct Costs	**$23.6**
Post-Excavation Construction and Long-Term O&M	**$27.8**
TOTAL ESTIMATED COST	**$77**
COST ESTIMATE RANGE (-20%/+30%)	**$62 – $100**

6.3.7.8 State Acceptance

Commonly in FS reports, the criterion of State Acceptance is evaluated following comment on the FS report and on the RAP. However, for the former Kast Property there is ample public record to allow an informed evaluation of RWQCB's position to be stated and evaluated in this Revised FS Report.

In its comments on the FS Report and on the RAP, RWQCB has stated that it does not believe that Alternative 5B would meet the requirements for remedy selection, primarily based on the following issues identified by RWQCB:

- An excavation to 3 ft bgs may not be sufficient to address nuisance caused by the waste at the Site.
- Alternative 5B would not protect residents from exposure during post-remediation excavation of residential hardscape on their properties.
- Alternative 5B would not protect residents from exposure during some types of residential activities such as gardening or small project excavations.
- Alternative 5B would leave a considerable mass of waste in Site soil that could continue to leach to groundwater.
- Alternative 5B does not meet the requirements of Resolution 92-49.

6.3.7.9 Consistency with Resolution 92-49

Section 6.2.2 sets forth an assessment of the consistency of excavation of remedial alternatives with Resolution 92-49. The same considerations apply to this Alternative.

6.3.7.10 Social Considerations

Alternative 5B would have a relatively low-to-moderate social impact. An estimated 202 properties would be affected by excavation and 221 by SVE/bioventing. Excavation and backfill would take less time than for Alternative 4B due to elimination of removal, excavation beneath, and replacement of residential hardscape.

6.3.7.11 Sustainability

Alternative 5B would create fewer greenhouse gas emissions from equipment than 4B since less soil and hardscape would need to be transported and excavated. Alternative 5B would require less than half the number of truckloads compared with Alternative 4C. Alternative 5B would require more landfill space than Alternatives 4B – 4E, and approximately the same amount of landfill space as Alternatives 5C, 5D, 5E and 7.

6.3.8 Detailed Evaluation of Alternative 5C

Alt	Existing ICs	Sub-slab Vapor Intrusion Mitigation	Excavate to 5 ft	Excavate Beneath Residential Hardscape	Groundwater MNA and Contingency Groundwater Remediation	Remove Mobile LNAPL	SVE / Bioventing
5C	X	X	X	N/A	X	X	X

6.3.8.1 Overall Protection of Human Health and the Environment

Alternative 5C would have similar issues as Alternative 5B. No removal of residential hardscape would occur and no excavation would be conducted beneath residential hardscape in either alternative. The City of Carson does not require that homeowners obtain a permit or notify the City prior to removing residential hardscape from their property. Because of the lack of a permitting or notification requirement, Alternative 5C, which does not include excavation of impacted soils beneath residential hardscape, is not expected to be as protective as alternatives which include excavation beneath residential hardscape. For Alternative 5C to be protective, an additional LUC or a notification system would be required to ensure notification to Shell for residential hardscape removal, but it would not be effective absent homeowner agreement and cooperation.

Excavation of the upper 5 feet of soil and replacement with clean soil would prevent most contact with impacted soils, with the possible exception of excavation for swimming pool installation. The institutional controls discussed previously would also apply to this alternative.

Mitigation of vapor intrusion pathways, SVE/bioventing use, and groundwater remediation would be the same as for Alternative 5B, and so would be equally protective.

6.3.8.2 Compliance with ARARs

Alternative 5C would meet the identified ARARs. The ARARs that may be applicable for one or more of the technologies that this alternative comprises are identified in **Tables 6-2** and **6-3**. A separate assessment of this alternative's consistency with State Water Resources Control Board Resolution 92-49 is set forth in Section 6.3.7.8.

6.3.8.3 Long-term Effectiveness and Permanence

Because of the lack of a permitting or notification requirement, Alternative 5C, which does not include excavation of impacted soils beneath residential hardscape, is not expected to be as effective or permanent in the long term as alternatives which include excavation of impacted soil beneath residential hardscape.

6.3.8.4 Reduction of Toxicity, Mobility and Volume through Treatment

The following technologies included in this alternative involve treatment of the media: offsite treatment/recycling of excavated soils, SVE/bioventing, groundwater treatment through contingency groundwater remediation, and mobile LNAPL removal. These treatment technologies would result in a high degree of reduction of toxicity, mobility, and volume from the Site, similar to Alternatives 4B – 4E.

6.3.8.5 Short-term Effectiveness

Excavating an additional 2 feet of soil relative to Alternative 5B would result in a longer period of potential exposure to impacted soil, and therefore greater exposure to the community and workers than for Alternative 5B. The short-term effectiveness of sub-slab vapor intrusion mitigation, SVE/bioventing, and mobile LNAPL removal and contingency groundwater remediation would be similar to Alternative 5B.

Based on the short-term benefits and risks, short-term effectiveness through careful planning and execution is moderate.

6.3.8.6 Implementability

Implementability of Alternative 5C is moderate. The same implementability issues that were discussed for Alternative 4C apply to Alternative 5C.

6.3.8.7 Estimated Cost

The cost estimate for Alternative 5C is contained in **Table 6-9**. Alternative 5C has a moderately high cost. A cost estimate summary follows:

Alternative 5C Remedial Cost Estimate	
Category	**Estimated Cost ($ millions)**
Demolition	**---**
Excavate, Backfill, and Associated Costs	**$37.2**
Other Direct Costs	**$29.5**
Post-Excavation Construction and Long-Term O&M	**$27.8**
TOTAL ESTIMATED COST	**$95**
COST ESTIMATE RANGE (-20%/+30%)	**$76 – $124**

6.3.8.8 State Acceptance

Commonly in FS reports, the criterion of State Acceptance is evaluated following comment on the FS report and on the RAP. However, for the former Kast Property there is ample public record to allow an informed evaluation of RWQCB's position to be stated and evaluated in this Revised FS Report.

In its comments on the FS Report and on the RAP, RWQCB has stated that it does not believe that Alternative 5C would meet the requirements for remedy selection, primarily based on the following issue identified by RWQCB:

- Alternative 5C would not protect residents from exposure during post-remediation excavation of residential hardscape on their properties.
- Alternative 5C therefore does not meet the requirements of Resolution 92-49.

6.3.8.9 Consistency with Resolution 92-49

Section 6.2.2 sets forth an assessment of the consistency of excavation of remedial alternatives with Resolution 92-49. The same considerations apply to this alternative.

6.3.8.10 Social Considerations

Alternative 5C would have the same social impacts as Alternative 4C, except there would be none of the issues associated with the removal of residential hardscape. Not removing residential hardscape decreases the number of truck trips and the inconvenience of not having a driveway or walkways, and the residents could return to their homes sooner. An estimated 202 properties would be affected by excavation and 221 by SVE/bioventing.

6.3.8.11 Sustainability

Alternative 5C would have the sustainability considerations as Alternative 4C. Alternative 5C would not require the removal or disposal of residential hardscape or the soil below residential hardscape and there would be fewer greenhouse gas emissions associated with the larger volume of impacted soil excavated. Alternative 5C would require less than half the number of truckloads compared with Alternative 4C. Alternative 5C would require more landfill space than Alternatives 4B – 4E, and approximately the same amount of landfill space as Alternatives 5B, 5D, 5E and 7.

6.3.9 Detailed Evaluation of Alternative 5D

Alt	Existing ICs	Sub-slab Vapor Intrusion Mitigation	Excavate to 5 ft with Additional Targeted Excavation to 10 ft	Excavate Beneath Residential Hardscape	Groundwater MNA and Contingency Groundwater Remediation	Remove Mobile LNAPL	SVE / Bioventing
5D	X	X	X	N/A	X	X	X

6.3.9.1 Overall Protection of Human Health and the Environment

Alternative 5D would have similar issues as Alternative 5C. No removal of residential hardscape would occur and no excavation would be conducted beneath residential hardscape in either alternative. The City of Carson does not require that homeowners obtain a permit or notify the City prior to removing residential hardscape from their property. Because of the lack of a permitting or notification requirement, Alternative 5D, which does not include excavation of impacted soils beneath residential hardscape, is not expected to be as protective as alternatives which include excavation beneath residential hardscape. For Alternative 5D to be protective, an additional LUC or a notification system would be required to ensure notification to Shell for residential hardscape removal, but it would not be effective absent homeowner agreement and cooperation.

Initial excavation of the upper 5 feet of soil and replacement with clean soil would prevent most contact with impacted soils, with the possible exception of excavation for swimming pool installation. Additional targeted excavation of soil > 5 feet bgs and ≤10 feet bgs and replacement with CLSM and clean soil would mitigate contact with impacted soils in exposed areas. The institutional controls discussed under Alternative 5B and 5C would also apply to this alternative.

Mitigation of vapor intrusion pathways, SVE/bioventing use, and groundwater remediation would be the same as for Alternative 5B and 5C, and so would be equally protective.

6.3.9.2 Compliance with ARARs

Alternative 5D would meet the identified ARARs. The ARARs that may be applicable for one or more of the technologies that this alternative comprises are identified in **Tables 6-2** and **6-3**. A separate assessment of this alternative's consistency with State Water Resources Control Board Resolution 92-49 is set forth in Section 6.3.8.8.

6.3.9.3 Long-term Effectiveness and Permanence

Because of the lack of a permitting or notification requirement, Alternative 5D, which does not include excavation of impacted soils beneath residential hardscape, is not expected to be as effective or permanent in the long term as alternatives which include excavation of impacted soil beneath residential hardscape.

6.3.9.4 Reduction of Toxicity, Mobility and Volume through Treatment

The following technologies included in this alternative involve treatment of the media: offsite treatment/recycling of excavated soils, SVE/bioventing, groundwater treatment through contingency groundwater remediation, and mobile LNAPL removal. These treatment technologies would result in a high degree of reduction of toxicity, mobility, and volume from the Site, similar to Alternatives 4B, 4C, 4D, and 4E.

6.3.9.5 Short-term Effectiveness

Based on the short-term benefits and risks, which are similar to Alternative 4D, the short-term effectiveness is low.

6.3.9.6 Implementability

Implementability for Alternative 5D is difficult, for the same reasons discussed under Alternative 4D.

6.3.9.7 Estimated Cost

The cost estimate for Alternative 5D is contained in **Table 6-10**. Alternative 5D has a high cost. A cost estimate summary follows:

Alternative 5D Remedial Cost Estimate	
Category	**Estimated Cost ($ millions)**
Demolition	**---**
Excavate, Backfill, and Associated Costs	**$40.9**
Other Direct Costs	**$35.5**
Post-Excavation Construction and Long-Term O&M	**$28.1**
TOTAL ESTIMATED COST	**$104**
COST ESTIMATE RANGE (-20%/+30%)	**$83 – $135**

6.3.9.8 State Acceptance

Commonly in FS reports, the criterion of State Acceptance is evaluated following comment on the FS report and on the RAP. However, for the former Kast Property there is ample public record to allow an informed evaluation of RWQCB's position to be stated and evaluated in this Revised FS Report.

In its comments on the FS Report and on the RAP, RWQCB has stated that it does not believe that Alternative 5D would meet the requirements for remedy selection, primarily based on the following issue identified by RWQCB:

- Alternative 5D would not protect residents from exposure during post-remediation excavation of residential hardscape on their properties.
- Alternative 5D therefore does not meet the requirements of Resolution 92-49.

6.3.9.9 Consistency with Resolution 92-49

Section 6.2.2 sets forth an assessment of the consistency of remedial alternatives that include excavation with Resolution 92-49. The same considerations apply to this alternative.

6.3.9.10 Social Considerations

Alternative 5D would have the same social impacts as Alternative 4D, except there would be none of the issues associated with the removal of residential hardscape. Alternative 5D has an added social impact because the excavation and soil replacement would take longer than Alternatives 5B or 5C because of additional soil removal, shoring or use of auger equipment, and utility removal and replacement. Not removing residential hardscape decreases the number of truck trips and the inconvenience of not having a driveway or walkways, and the residents could return to their homes sooner.

An estimated 202 properties would be affected by excavation and 221 by SVE/bioventing.

6.3.9.11 Sustainability

Alternative 5D has more significant negative sustainability effects than discussed for 5B and 5C. Alternative 5D would create more greenhouse gas emissions from equipment since more soil would need to be transported and excavated. Alternative 5D would release more methane to the atmosphere. While fire and explosion hazards have not been identified at any residence due to methane concentrations from degradation of hydrocarbons in soil vapor, this would be considered a greenhouse gas emission and therefore a detrimental impact to air quality. The amount of greenhouse gases released would be far less with excavation to 3 feet under Alternative 5B than to 5 feet or to 10 feet, even if just in targeted areas. Alternative 5D would also use more landfill space or recycling capacity because of the larger volume of soil excavated. There may also be increased waste due to excavating and replacing utilities.

6.3.10 Detailed Evaluation of Alternative 5E

Alt	Existing ICs	Sub-slab Vapor Intrusion Mitigation	Excavate to 10 ft	Excavate Beneath Residential Hardscape	Groundwater MNA and Contingency Groundwater Remediation	Remove Mobile LNAPL	SVE / Bioventing
5E	X	X	X	N/A	X	X	X

6.3.10.1 Overall Protection of Human Health and the Environment

Alternative 5E would have similar protectiveness considerations as Alternatives 5B, 5C and 5D. No removal of residential hardscape would occur and no excavation would be conducted beneath residential hardscape in either alternative. The City of Carson does not require that homeowners obtain a permit or notify the City prior to removing residential hardscape from their property. Because of the lack of a permitting or notification requirement, Alternative 5E, which does not include excavation of impacted soils beneath residential hardscape, is not expected to be as protective as alternatives which includes excavation beneath residential hardscape. For Alternative 5E to be protective, an additional LUC or a notification system would be required to ensure notification to Shell for residential hardscape, but it would not be effective absent homeowner agreement and cooperation.

Excavation of the upper 10 feet of soil and replacement with clean soil would mitigate contact with impacted soils in exposed areas. The institutional controls discussed under Alternative 5B, 5C, and 5D would also apply to this alternative.

Mitigation of vapor intrusion pathways, SVE/bioventing use, and groundwater remediation would be the same as for Alternatives 5B, 5C, and 5D and so would be equally protective.

6.3.10.2 Compliance with ARARs

Alternative 5E would meet the identified ARARs. The ARARs that may be applicable for one or more of the technologies that this alternative comprises are identified in **Tables 6-2** and **6-3**. A separate assessment of this alternative's consistency with State Water Resources Control Board Resolution 92-49 is set forth in Section 6.3.8.8.

6.3.10.3 Long-term Effectiveness and Permanence

Because of the lack of a permitting or notification requirement, Alternative 5E, which does not include excavation of impacted soils beneath residential hardscape, is not expected to be as effective or permanent in the long term as alternatives which include excavation of impacted soil beneath residential hardscape.

6.3.10.4 Reduction of Toxicity, Mobility and Volume through Treatment

The following technologies included in this alternative involve treatment of the media: offsite treatment/recycling of excavated soils, SVE/bioventing, groundwater treatment, and mobile LNAPL removal. These treatment technologies would result in a high degree of reduction of toxicity, mobility, and volume from the Site, similar to Alternatives 4B, 4C, 4D, and 4E.

6.3.10.5 Short-term Effectiveness

Based on the short-term benefits and risks, which are similar to Alternative 4D, 4E, and 5D, the short-term effectiveness of Alternative 5E is very low.

6.3.10.6 Implementability

Implementability for Alternative 5E is very difficult, for the same reasons discussed under Alternative 4E.

6.3.10.7 Estimated Cost

The cost estimate for Alternative 5E is contained in **Table 6-11**. Alternative 5E has an extraordinarily high cost. It is the second highest cost alternative. A cost estimate summary follows:

Alternative 5E Remedial Cost Estimate	
Category	**Estimated Cost ($ millions)**
Demolition	**---**
Excavate, Backfill, and Associated Costs	**$71.4**
Other Direct Costs	**$46.5**
Post-Excavation Construction and Long-Term O&M	**$28.5**
TOTAL ESTIMATED COST	**$146**
COST ESTIMATE RANGE (-20%/+30%)	**$117 – $190**

6.3.10.8 State Acceptance

Commonly in FS reports, the criterion of State Acceptance is evaluated following comment on the FS report and on the RAP. However, for the former Kast Property there is ample public record to allow an informed evaluation of RWQCB's position to be stated and evaluated in this Revised FS Report.

In its comments on the FS Report and on the RAP, RWQCB has stated that it does not believe that Alternative 5E would meet the requirements for remedy selection, primarily based on the following issue identified by RWQCB:

- Alternative 5E would not protect residents from exposure during post-remediation excavation of residential hardscape on their properties.
- Alternative 5E therefore does not meet the requirements of Resolution 92-49.

6.3.10.9 Consistency with Resolution 92-49

Section 6.2.2 sets forth an assessment of the consistency of excavation of remedial alternatives with Resolution 92-49. Shell believes that Alternative 5E would not meet the requirements of Resolution 92-49.

6.3.10.10 Social Considerations

Alternative 5E would have a high level of social impact. Alternative 5E has the same impacts that were discussed for Alternatives 5B, 5C, and 5D. Alternative 5E has an added social impact because the excavation and soil replacement would take many days longer than Alternatives 5B, 5C, or 5D because of additional soil removal, use of shoring or auger excavation, and utility removal and restoration. There would be increased truck traffic from Alternative 5E due to more soil and hardscape being removed from a greater number of properties than for any other alternative, and due to the extensive lengthy disruption of the community.

6.3.10.11 Sustainability

Alternative 5E would release more greenhouse gases to the atmosphere than Alternatives 5B, 5C or 5D. While fire and explosion hazards have not been identified at any residence due to methane concentrations from degradation of hydrocarbons in soil vapor, this would be considered a greenhouse gas emission and therefore a detrimental impact to air quality. Such emissions would be far less with excavation to 3 feet under Alternative 5B than to 5 feet or especially 10 feet.

Each alternative requires the treatment and recycling or disposal of some impacted soil in landfills, along with some recycled materials. Landfill space and treatment capacity are finite and an increased volume of soil being disposed of in landfills or recycled reduces the availability of these valuable resources. Alternative 5E would use more landfill space or recycling capacity because of the larger volume of soil excavated.

6.3.11 Detailed Evaluation of Alternative 7

Alt	Existing ICs	Sub-slab Vapor Intrusion Mitigation	Cap Site	Excavate	Groundwater MNA and Contingency Groundwater Remediation	Remove Mobile LNAPL	SVE / Bioventing
7	X	X	X	N/A	X	X	X

6.3.11.1 Overall Protection of Human Health and the Environment

Alternative 7 would achieve the human health goal for infrequent exposure to deep soils and for nuisance, but would not achieve the other soil goals in the short-term. Implementation of this alternative would take longer to meet groundwater SSCGs, as less impacted soils would be removed by excavation than any other alternatives considered.

Sub-slab depressurization would mitigate the potential vapor intrusion pathway at properties where sub-slab soil vapor does not meet the RAO as developed in the

HHRA. A SSD system would keep soil vapors beneath a building from entering the building.

COCs would be less likely to leach into groundwater due to the large reduction in stormwater and irrigation water passing through the soil. In order to protect groundwater for designated beneficial uses, such as municipal supply, COCs in soil and groundwater would be reduced through SVE/bioventing, mobile LNAPL removal, groundwater MNA, and contingency groundwater remediation.

6.3.11.2 Compliance with ARARs

Alternative 7 would meet the identified ARARs. The ARARs that may be applicable for one or more of the technologies that comprise this alternative are identified in **Tables 6-2** and **6-3**. A separate assessment of this alternative's consistency with State Water Resources Control Board Resolution 92-49 is set forth in Section 6.3.9.8.

6.3.11.3 Long-term Effectiveness and Permanence

The combination of technologies used for Alternative 7 are anticipated to be highly effective at reducing exposure to COCs in the long-term. The difference compared to the excavation alternatives (4B-E and 5B-E) is the method of exposure reduction. Excavation alternatives remove COCs directly from the Site, while for Alternative 7 those COCs would be removed through longer-term SVE/bioventing. Additionally, COCs would be less likely to leach into groundwater in this alternative than in Alternative 4B due to the reduction in stormwater and irrigation water passing through the soil. In the long term, RAOs would be met for the Site. As with other alternatives, long-term monitoring would assess effectiveness of continuing remedial systems.

6.3.11.4 Reduction of Toxicity, Mobility and Volume through Treatment

The following technologies included in this alternative involve treatment of the media: SVE/bioventing, groundwater treatment, and mobile LNAPL removal. These treatment technologies would result in a significant degree of reduction of toxicity, mobility, and volume from the Site over the long term.

6.3.11.5 Short-term Effectiveness

Alternative 7 would interrupt the exposure pathway for Site soils through capping exposed soils. It would remove COCs in the upper 6 inches of soil to prepare for Site capping, which is less excavation than for the other retained alternatives. As a result, this alternative would cause less of the short-term effects associated with excavating 3 or more feet impacted soil.

The short-term effectiveness of sub-slab vapor intrusion mitigation, SVE/bioventing, mobile LNAPL removal and contingency groundwater remediation is relatively high.

6.3.11.6 Implementability

Implementability of Alternative 7 is moderate.

Alternative 7 would involve capping exposed soil on each of 285 properties, whereas Alternative 4E and 5E would require excavation on 224 and Alternatives 4B-4D, and 5B-5D would include excavation on 202 properties. SVE/bioventing would be conducted on 221 properties.

Excavation would be minimal for Alternative 7, primarily for clearing and grubbing and installation of SVE/bioventing wells and piping. Utility lines would be below the excavation depth.

Alternative 7 also would require an institutional control so that the residents do not come into contact with the COCs contained below the cap. Adoption of new institutional controls would increase the administrative requirements, and implementation would depend upon homeowner agreement to record a restrictive covenant at each property. A SWPPP would be required for Alternative 7 due to the increase in runoff caused by the impermeable cap.

6.3.11.7 Estimated Cost

The cost estimate for Alternative 7 is contained in **Table 6-12**. Alternative 7 has the lowest cost of the final alternatives. A cost estimate summary is shown below:

Alternative 7 Remedial Cost Estimate	
Category	**Estimated Cost ($ millions)**
Demolition	**---**
Excavate, Backfill, and Associated Costs	**$20.9**
Other Direct Costs	**$6.4**
Post-Excavation Construction and Long-Term O&M	**$6.4**
TOTAL ESTIMATED COST	**$34**
COST ESTIMATE RANGE (-20%/+30%)	**$27 – $44**

6.3.11.8 State Acceptance

Commonly in FS reports, the criterion of State Acceptance is evaluated following comment on the FS report and on the RAP. However, for the former Kast Property there is ample public record to allow an informed evaluation of RWQCB's position to be stated and evaluated in this Revised FS Report. It is anticipated that RWQCB would likely conclude the following for Alternative 7:

- Alternative 7 would meet the threshold criteria of Overall Protection of Human Health and the Environment.
- Alternative 7 would not provide the best performance of all alternatives with respect to the balancing criteria.
- Alternative 7 would not be deemed to be consistent with Resolution 92-49.
- The modification in land use, which could not accommodate normal residential landscape, would likely be judged by RWQCB to be less desirable to the community.

RWQCB would likely not select Alternative 7 for implementation as the Site remedy,

6.3.11.9 Consistency with Resolution 92-49

Section 6.2.2 sets forth an assessment of the consistency of remedial alternatives that include excavation with Resolution 92-49. Alternative 7 is judged to be less consistent with Resolution 92-49.

6.3.11.10 Social Considerations

Alternative 7 would have a very high social impact. A cap over all Site landscaped areas would impact residents' enjoyment of their homes. All existing landscaping would be removed, including favored trees or shrubs, and all planting would need to be done above ground such as in planter boxes. No exposed-soil landscaped areas would remain after implementation. This would have a more long-term effect on the community than any of the alternatives involving excavation.

During construction, significant air quality, noise, and traffic impacts would be anticipated. These impacts are expected to be able to be mitigated. Surrounding neighborhoods would be impacted to a lesser extent by heavy truck traffic. It is anticipated that installation of a cap would take about 1.4 years for implementation on the entire Site.

6.3.11.11 Sustainability

Because it involves only minimal excavation, Alternative 7 would be the most green remediation alternative as compared to Alternatives 4 and Alternatives 5. Alternative 7 requires less use of trucks, excavators or landfill space than other alternatives.

Alternative 7 may affect stormwater quality or runoff in the long term, which would also reduce groundwater recharge, due to the inability for stormwater to infiltrate into the cap. This sustainability issue is unique to Alternative 7.

7. COMPARATIVE EVALUATION OF ALTERNATIVES

In this section, the retained remedial alternatives are compared by using the detailed analysis criteria. The purpose of this comparative analysis is to identify the relative advantages and disadvantages of each final remedial alternative (Alternatives 4B-E, 5B-E and 7) and to provide a basis for recommending a preferred remedial alternative.

In **Table 7-1**, each final remedial alternative is assigned a ranking for each detailed analysis criterion, except that the two threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs are not provided with a numeric ranking because the threshold of protectiveness or compliance must be met, and is met, by each remaining alternative (except for the no action alternative).

Rankings range from "low" to "high" and are accompanied with a numeric ranking from 1 to 5[10]. At the conclusion of the comparative analysis, the recommended remedial alternative is identified.

7.1 Overall Protection of Human Health and the Environment

Alternative 1, No Action, does not provide adequate protection of human health and the environment. No further assessment or comparison with this alternative is provided.

With respect to overall protection of human health and the environment, comparison points for retained alternatives follow:

- Alternatives 4B, 4C, 4D, 4E, and 7 protect human health and the environment through impacted soil removal, treatment, and existing institutional controls or capping to prevent exposure. The majority of these benefits occur under Alternative 4B; Alternatives 4C, 4D, and 4E provide at best limited additional protection. 4C is more protective if it is assumed residents would periodically dig below 3 feet without contacting the County for a permit. 4D provides targeted additional mass removal where it would be most effective. 4E provides further mass removal but of lower concentration impacted soils, at an economically infeasible cost. RAOs are met equally in the long term.
- Alternatives 4B, 4C, 4D, and 4E are more protective than Alternatives 5B, 5C, 5D, and 5E, which leave impacted soil beneath residential hardscape without controls on hardscape removal by a homeowner to access to such soils.

[10] A numeric ranking of "1" is lowest, or worst; "5" is highest, or best. With respect to cost, "1" is most expensive; "5" is least expensive.

- Groundwater SSCGs would be met by all alternatives after excavation (Alternatives 4B – 4E and 5B – 5E) or after capping (Alternative 7). It is likely that groundwater SSCGs would be met in a very slightly reduced timeframe for alternatives which remove more mass.

7.2 Compliance with ARARs

Each alternative is capable of complying with ARARs. The excavation alternatives perform equally well with respect to compliance. Alternative 7 would pose significant issues associated with capping of the entire Site, but ARARs could be met.

7.3 Long-term Effectiveness and Permanence

Each alternative would be effective and permanent in the long-term. Comparison points follow:

- Alternatives 4B – 4E remove more impacted soil than Alternatives 5B – 5E, which leave impacted soil beneath residential hardscape.
- Alternatives 5B – 5E would not be effective in preventing residential contact with impacted soils beneath residential hardscape. Without supplemental institutional controls, which could be difficult to implement, Alternatives 5B – 5E would not be as effective in the long term.
- Alternative 7 removes the least amount of impacted soil initially but also would eventually meet remedial goals.
- Although Alternatives 4E and 5E would appear to provide for a greater removal of impacted soil through excavation than 4A – 4D or 5A – 5D (although the volume difference varies among the alternatives), due to shoring and setback requirements, utility protection requirements, and the high difficulty of excavating back yards to 10 feet, Alternatives 4E and 5E would still leave a substantial amount of impacted soil in place, which will be addressed in the future through SVE/bioventing.
- Alternatives 4C and 4D are shown to provide long-term effectiveness by reducing potential for inadvertent residential contact and reducing mass more than Alternatives 4B or Alternatives 5B – 5E.

7.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Each alternative would provide for significant reduction of toxicity, mobility and volume through treatment. Each alternative would employ the following technologies in treatment of the media: offsite treatment and recycling of most excavated soils, SVE/bioventing, mobile LNAPL removal, groundwater MNA, and contingency groundwater remediation. Comparison points follow:

- In the short term, Alternatives 4C and 5C would provide for a slightly greater degree of reduction in impacted soil because of the extra 2 feet of excavation compared with Alternatives 4B and 5B.
- In the short term, Alternatives 4D and 5D would provide for a greater degree of reduction in impacted soil because of the additional targeted excavation to 10 feet bgs compared with Alternatives 4C and 5C.
- In the short term, Alternatives 4E and 5E would provide incremental reduction in impacted soil compared with Alternatives 4D and 5D.
- Alternatives 4B – 4E, 5B – 5E, and 7 would provide for the same degree of reduction in toxicity, mobility, and volume through treatment in the long term.

7.5 Short-term Effectiveness

Alternatives 4A – 4E would perform equally well with respect to short-term effectiveness as their corresponding Alternatives 5A – 5E. Specific comparative points follow:

- Alternatives 4B and 5B would require excavation of 3 feet of soil from affected residential properties.
- Alternatives 4C and 5C would require excavation of 5 feet of soil from affected residential properties, but may require shoring of the excavation, setbacks from structures, sloped excavation sidewalls, and/or slot trenching in accordance with geotechnical requirements. These would reduce the area of excavations and reduce the effectiveness of the alternative, as would the need to avoid excavating near the water mains and other utilities that are located in the front yards at approximately 50% of the properties.
- Alternatives 4D and 5D would require excavation of 5 feet of soil from affected residential properties and targeted deeper excavation to 10 feet bgs, with more significant short-term effectiveness issues than Alternatives 4C and 5C.
- The excavation of additional soil in Alternatives 4C, 4D, and 4E and corresponding 5C, 5D, and 5E would result in progressively more days when impacted soil would be exposed, and therefore a greater potential exposure to the community and workers, and overall longer period of implementation than Alternatives 4B or 5B.

- Alternatives 4B and 5B can be implemented in much less time than Alternatives 4C and 5C, which correspondingly can be implemented in less time than Alternatives 4D and 5D. Alternatives 4E and 5E would take the longest time to implement. The 5B-5E Alternatives can be implemented in less time than the corresponding 4B – 4E Alternatives. Alternative 7 could be implemented in the least amount of time, although similar to Alternative 5B:[11]
  - Alternative 4B: 3.0 years
  - Alternative 4C: 4.0 years
  - Alternative 4D: 5.1 years
  - Alternative 4E: 7.8 years
  - Alternative 5B: 2.5 years
  - Alternative 5C: 3.0 years
  - Alternative 5D: 4.0 years
  - Alternative 5E: 5.6 years
  - Alternative 7: 1.1 years
- Alternatives 4B – 4E require removal and disposal of residential hardscape, whereas Alternatives 5B – 5E do not require removal of hardscape. Alternatives 4B – 4E would therefore be more disruptive and take longer to implement.
- Alternative 7 would remove COCs in the upper 6 inches of soil to prepare for Site capping. As a result, this alternative would cause less of the short-term effects associated with excavating 3 feet or 5 feet, and the capping would provide immediate disruption of exposure pathways.
- As noted, Alternatives 4E and 5E would require the most time to complete and would result in the most disruption of the Site and of the community.

7.6 Implementability

There are significant differences in implementability of the alternatives. Comparison points follow:

- Alternatives 4B, 4C, 4D, 5B, 5C, and 5D would include excavation at 202 properties. Alternative 4E and 5E would require excavation at 224 properties,

[11] The timeframes presented include the active excavation and backfill portion of the remedy. Additional time would be required up-front for preparation and approval of remedial design, permitting, and other pre-construction activities. Additional time would be required after active remedial action is complete for SVE installation and startup.

and Alternative 7 would involve excavation and capping at 285 properties. Each alternative would require SVE/bioventing at 221 properties. Sub-slab mitigation through a sub-slab depressurization (SSD) system would be used to mitigate the potential vapor intrusion pathway at the Site at 28 properties. In addition, while the data do not indicate that vapor intrusion is an issue at any of the residences, Shell is prepared to offer installation of a sub-slab mitigation system to any of the homeowners in the Carousel neighborhood to alleviate concerns about potential impacts to their indoor air from the Site.

- Alternatives 4B and 5B, with excavation to 3 feet, would not be expected to encounter water mains and other utilities can readily be protected in place, as opposed to deeper excavations which would encounter these utilities.
- Excavation would be minimal for Alternative 7. Utility lines would likely not be affected.
- Alternatives 4C, 4D, 4E, 5C, 5D, and 5E would require shoring, slot trenching, or other means to excavate to a depth of 5 feet. Excavation to 5 feet would involve significant utility disruption, potentially including disruption of water supply to large parts of the community due to the presence of asbestos-cement (transite) water main pipelines at a depth of approximately 3 to 3½ feet in yards of approximately half of the properties in the tract.
- Alternatives 4D, 4E, 5D, and 5E would require additional shoring, slot trenching, or other means to additionally excavate to 10 feet bgs. Excavation to 10 feet bgs would likely require specialized construction equipment, adding to technical difficulty, duration, and cost.
- Alternative 7 would also require additional institutional controls including the recording of restrictive covenants so that the residents do not come into contact with the COCs contained below the impervious cap. Adoption of new institutional controls would increase the administrative infeasibility compared with the excavation alternatives. Special runoff measures, including a SWPPP, would likely be required for Alternative 7 due to the increase in runoff and potential degradation in stormwater quality caused by the impermeable cap.
- Comparatively, Alternative 4E involves the longest overall time to implement, greatest volume of soils excavated, the largest amount of clean soil brought back the Site, the greatest number of properties affected, the longest period of remediation per property, the greatest amount of shoring, increased equipment requirements, and the most likely chance of significantly affecting utility lines.

7.7 Estimated Cost

The estimated costs of the alternatives are presented in **Table 6-4** through **Table 6-12** with capital and 30-year O&M costs identified. A summary of estimated costs follows:

- Alternative 4B: $76 million - $124 million
- Alternative 4C: $97 million - $157 million
- Alternative 4D: $106 million - $172 million
- Alternative 4E: $163 million - $265 million
- Alternative 5B: $62 million - $100 million
- Alternative 5C: $76 million - $124 million
- Alternative 5D: $83 million - $135 million
- Alternative 5E: $117 million - $190 million
- Alternative 7: $27 million - $44 million

7.8 State Acceptance

This criterion normally is evaluated following comment on the FS and on the RAP. However, RWQCB has provided ample public record for an informed evaluation of their position to be stated and evaluated.

When compared with the evaluation of other alternatives, Alternative 4B meets the threshold criteria and provides the best balance of all alternatives against the balancing criteria and each other evaluation criterion (see Section 7 and Section 8). However, in its comments on the March 10, 2014 FS Report and on the RAP, RWQCB has stated that it does not concur with this conclusion, primarily based on the following issues identified by RWQCB regarding an excavation to 3 feet bgs:

- An excavation to 3 ft bgs may not be sufficient to address potential nuisance caused by the waste at the Site.

- It may not protect residents from exposure during the some types of residential activities.

- It would leave a considerable mass of waste in Site soil that can continue to leach to groundwater.

- It does not meet the requirements of Resolution 92-49.

Based on RWQCB's April 30, 2014 comment letter and subsequent discussions, Shell believes that excavation to 5 feet would be more preferable to RWQCB than excavation to 2 or 3 feet, however RWQCB has also has asked Shell to also explore the feasibility of technologies to excavate to 10 feet where practicable. Shell has done so, and has included an assessment of mass removal against incremental cost of achieving this mass removal (See **Table 6-1**). Shell believes Alternative 4D would likely be more acceptable to RWQCB than Alternative 1, 4A, 4B, 4C, 4E, 5B – 5E, or 7, for the following reasons:

- An excavation to 5 ft bgs with targeted excavation to 10 ft bgs would be sufficient to address RWQCB's concerns regarding nuisance caused by the waste at the Site.
- Alternative 4D would address RWQCB's concerns regarding protection of residents from exposure during some types of residential activities such as gardening or small project excavations.
- Alternative 4D would remove a larger mass of waste in Site soil than would be removed under Alternatives 4B or 4C.
- It is logical to assume that this even larger amount of mass removal under Alternative 4D would, in some incremental (but not measurable) way, reduce the operating time of the SVE/bioventing system, and therefore the time required to achieve groundwater cleanup goals, when compared with Alternatives 4B or 4C.

7.9 Consistency with Resolution 92-49

An objective assessment of incremental benefits shows that Alternative 4B meets the threshold criterion of protectiveness of human health and the environment, and it also complies with ARARs. Alternative 4B also results in the safe continued use of the Site for its current residential purpose. It minimizes social impacts, and therefore economic impacts, associated with Site COCs by removing those COCs and achieving the RAOs while preserving the neighborhood and resulting primarily in only short-term inconvenience to the residents. Alternative 4B would comply with Resolution 92-49.

Despite these findings, Shell recognizes that RWQCB has expressed concerns about the compliance of Alternative 4B with the requirements of Resolution 92-49. In its April 30, 2014 comment letter, RWQCB directed Shell to evaluate incremental costs in relation to incremental reduction in waste concentrations [RWQCB, 2014c]. Shell has included an assessment of incremental mass removal against the incremental cost of achieving this mass removal (See **Table 6-1**). It is anticipated that RWQCB may conclude that Alternative 4D performs better than Alternatives 1, 4A, or 4B with respect to this evaluation. Therefore, in response to RWQCB's concern, Alternative 4D is likely to be more acceptable to RWQCB than the other alternatives.

7.10 Social Considerations

There are significant differences in social considerations associated with the various alternatives. Comparison points follow:

- Alternative 4B and 5B would have the lowest (low-to-moderate) social impact. An estimated 202 properties would be affected by soil excavation, and an estimated 221 properties would be affected by SVE/bioventing. Excavation and backfill would take approximately 1.9 years and 1.5 years, respectively, for Alternative 4B and 5B.
- Alternative 4C and 5C would have a higher (moderately high) social impact compared with 4B and 5B. The same 202 properties would be affected by excavation, and 221 properties would be affected by SVE/bioventing. Excavation, shoring and backfill would take approximately 2.8 years for each of Alternatives 4C and 5C.
- Alternative 4D and 5D would have a higher (high) social impact compared with 4C and 5C. The same 202 properties would be affected by excavation, and 221 properties would be affected by SVE/bioventing. Excavation, shoring and backfill would take approximately 2.8 years for each of Alternatives 4D and 5D.
- Alternative 4E and 5E would have a higher (very high) social impact compared with 4D and 5D. More properties (224) would be affected by excavation, and 221 properties would be affected by SVE/bioventing. Excavation, shoring and backfill would take approximately 2.8 years for each of Alternatives 4E and 5E.
- Alternative 7 would have a very high social impact. A cap over Site landscaped areas would likely decrease the aesthetic appeal of the community. All planting would need to be done above ground (such as in planters). This would likely have a more long-term effect on the community than any of the alternatives involving excavation.

7.11 Sustainability

There are significant differences in sustainability associated with the various alternatives. Comparison points follow:

- Excavation alternatives require the use of excavation equipment and trucks that would create greenhouse gas emissions affecting air quality. As the time for remediation, the number of properties, and the number of truckloads increase, so do the greenhouse gas emissions and effects on air quality.

Alternative 4B would have less of an impact on air quality than Alternatives 4C, 4D, 4E, 5C, 5D, and 5E, but it is not as sustainable as Alternatives 5B or 7.

- Each alternative requires the treatment and recycling of impacted soil and some disposal of materials in landfills. Landfill space is finite and an increased volume of soil being disposed of in landfills reduces the availability of a valuable resource. Alternative 4B is more sustainable in this regard than Alternatives 4C, 4D, 4E, 5D, and 5E but not as sustainable as Alternatives 5B, 5C, or 7.
- Alternatives 4B – 4E create additional waste, much of it recyclable, as opposed to Alternatives 5B – 5E because of the removal of residential hardscape.
- Alternative 7 would be the most green remediation alternative as compared to Alternatives 4 and Alternatives 5. Alternative 7 requires minimal use of equipment, the least time to implement, and the lowest potential use of landfill space or recycling capacity.
- Alternative 7 may affect stormwater quality, groundwater recharge, or runoff in the long term due to the inability for stormwater to infiltrate into the cap. This sustainability issue is unique to Alternative 7.

8. PREFERRED REMEDIAL ALTERNATIVE

Based on the comparative evaluation of the remedial alternatives presented in Section 7, Shell recommends Alternative 4D for selection as the remedy for the Site. RWQCB has expressed concern that excavation of less than 5 feet depth in a residential setting could pose a continuing concern for residents of the community. RWQCB also is concerned about the limited mass removal that would be achieved through alternatives that do not excavate to 5 feet bgs. To accommodate RWQCB's request, Shell has further explored excavation to 5 feet and targeted excavation where practicable to 10 feet bgs, which is included in Alternative 4D.

Alternative 4D provides for excavation under both landscape and residential hardscape to 5 feet. Alternative 4D provides an incremental amount of mass removal at an incremental financial cost Shell is willing to incur. Alternative 4E, on the other hand, achieves incremental mass removal with no additional reduction of risk and at an unacceptably high incremental financial cost and excessive duration. Because Alternative 4D better meets the evaluation criteria than Alternative 4E, Alternative 4D is identified as the preferred remedial alternative, and is recommended for inclusion in the Revised RAP.

A recapitulation of Alternative 4D follows. Alternative 4D includes these elements:

- Excavation of soils to a depth of 5 feet bgs from both landscaped areas and areas covered by residential hardscape at properties where SSCGs are not met as identified in the HHRA, and targeted deeper excavation to 10 feet bgs for additional mass removal. Targeted deeper excavation would occur where an excavation to at least 5 feet is being conducted, where soil TPH concentrations exceed 10 times the cleanup goal for TPH as set forth in Section 3 of this Revised FS Report, and where excavation is not limited by physical constraints including utilities, setback requirements, or similar constraints. Such excavation could occur in all of a residential yard, or in parts of a residential yard and may occur in only front yards or back yards at some properties. Additionally, targeted deeper excavation would not occur in side yards due to physical working space constraints.

- Excavated areas and residential hardscape would be replaced to like conditions with a combination of CLSM (2-sack sand/cement slurry) and clean imported soils, new hardscape, and new landscape.

- Reservoir slabs would be removed where removal could be accomplished safely if they are encountered during excavations to 5 feet bgs or targeted deeper excavations to 10 feet bgs. They would not be removed if they lie outside the boundaries of an excavation or below the depth of excavation, because they do not require removal to meet RAOs.

- Sub-slab mitigation through a sub-slab depressurization (SSD) system would be used to mitigate the potential vapor intrusion pathway at the Site at 28 properties. In addition, while the data do not indicate that vapor intrusion is an issue at any of the residences, Shell is prepared to offer installation of a sub-slab mitigation system to any of the homeowners in the Carousel neighborhood to alleviate concerns about potential impacts to their indoor air from the Site. A SSD system creates a negative pressure below the slab of the building using a fan or similar device to remove vapor from beneath the slab and exhausting the vapor above the building. This process keeps vapors emanating from soil beneath a building from entering the building.

- SVE/bioventing would be included to address volatile petroleum hydrocarbons, VOCs and methane in soil vapor where appropriate and to promote degradation of residual hydrocarbons in the vadose zone soils. SVE wells would be installed in City streets and on residential properties, as appropriate. Wells would be flush-mounted in streets and would be generally not visible nor interfere with the appearance of a yard. Bioventing would work in conjunction with SVE and would use the same wells via cyclical operation of the SVE/bioventing system.

- Mobile LNAPL recovery will continue periodically where LNAPL has accumulated in monitoring wells (MW-3 and MW-12) to the extent technologically and economically feasible, and where a significant reduction in risk to groundwater would result. If mobile LNAPL accumulates in the future in other wells to a measurable thickness, LNAPL recovery will commence from those wells, and if LNAPL accumulates at a thickness of greater than 0.5 foot (six inches) in other wells, LNAPL will also be periodically recovered from those wells using a dedicated pump. The goal for mobile LNAPL recovery will be an end point of no measurable LNAPL accumulation in monitoring wells at the Site. In the future, Shell proposes to assess the economic and technical feasibility of continued hydraulic recovery of mobile LNAPL using LNAPL transmissivity (Tn) as a criterion. The Interstate Technology and Regulatory Council (ITRC) suggests that hydraulic recovery systems can practically recover LNAPL where the Tn is greater than 0.1 to 0.8 ft2/day and that "Further lowering of Tn is difficult and can be inefficient; that is, it can take very long to marginally reduce Tn without much benefit in terms of reduction of LNAPL mass, migration potential, risk, or longevity" [ITRC, 2009b]. Tn will be assessed at wells exhibiting sufficient

LNAPL thickness (at least 0.5 ft) using a baildown/slug test procedure as described by ASTM [2013].

- Monitored natural attenuation (MNA) would be implemented to meet SSCGs for groundwater. MNA could be paired with contingency groundwater remediation of oxidant injection in areas where Site-related COCs exceed 100x MCL if, after a five-year review following start of SVE/bioventing operations, the groundwater plume is not stable or decreasing. In addition, upgradient sources would need to be addressed by the overseeing agencies.

- Institutional controls would include reliance on existing LA County and City of Carson code provisions and permitting processes such that current and future residents are made aware of residual impacts and are restricted from exposure to residual impacts below a depth of 3 feet. The City of Carson has amended L.A. County Building Code Section 7003.1 (City of Carson Building Code §8105) to require a Grading Permit for excavations 3 feet or deeper. Because the City would be notified and approve excavations deeper than 3 feet via the permitting process, the City could readily inform residents and workers of other appropriate precautions necessary for excavations below 5 feet and targeted deeper excavations through this existing administrative processes, and also notify Shell that monitoring and disposal may be required.

- A number of permits would be required. Significant permits are as follows:
    - Grading Permit for each property excavated.
    - Excavation and Encroachment Permits from the City of Carson for equipment staging and operations, lane closures in public streets and sidewalks.
    - Traffic Management Plan as part of the Encroachment Permit Application.
    - Rule 1166 Permit from South Coast Air Quality Management District (SCAQMD) for excavation of VOC-impacted soils.
    - Permit to Construct/Operate for the SVE/bioventing system from SCAQMD.
    - Permit(s) for the Sub-slab Depressurization Systems from SCAQMD.
    - Plumbing and Electrical Permits would be needed if plumbing or electrical service is removed and replaced.
    - Permits for reconstruction of property features.

Alternative 4D will be carried forward into the RAP, where more detail associated with its implementation will be included.

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TABLES

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Table 2-1
Summary of Constituents of Concern

CAS Number	Chemical[1]	Soil		Soil Vapor, Sub-Slab		Soil Vapor, Non-Sub-Slab	
		COC	Site-Related COC[1]	COC	Site-Related COC[1]	COC	Site-Related COC[1]
Metals							
7440-36-0	Antimony	Yes	No	--	--	--	--
7440-38-2	Arsenic	Yes	Yes	--	--	--	--
7440-43-9	Cadmium	No[2]	No	--	--	--	--
18540-29-9	Chromium, Hexavalent	Yes[3]	No	--	--	--	--
7440-48-4	Cobalt	No[2]	No	--	--	--	--
7440-50-8	Copper	No[2]	No	--	--	--	--
7439-92-1	Lead	Yes	Yes	--	--	--	--
7440-28-0	Thallium	Yes	No	--	--	--	--
7440-62-2	Vanadium	No[2]	No	--	--	--	--
7440-66-6	Zinc	No[2]	No	--	--	--	--
PAHs							
56-55-3	Benzo (a) Anthracene	Yes	Yes	--	--	--	--
50-32-8	Benzo (a) Pyrene	Yes	Yes	--	--	--	--
205-99-2	Benzo (b) Fluoranthene	Yes	Yes	--	--	--	--
207-08-9	Benzo (k) Fluoranthene	Yes	Yes	--	--	--	--
218-01-9	Chrysene	Yes	Yes	--	--	--	--
53-70-3	Dibenz (a,h) Anthracene	Yes	Yes	--	--	--	--
193-39-5	Indeno (1,2,3-c,d) Pyrene	Yes	Yes	--	--	--	--
90-12-0	1-Methylnaphthalene	Yes	Yes	--	--	--	--
91-57-6	2-Methylnaphthalene	Yes	Yes	--	--	--	--
129-00-0	Pyrene	Yes	Yes	--	--	--	--
SVOCs							
121-14-2	2,4-Dinitrotoluene	Yes	No	--	--	--	--
117-81-7	Bis(2-Ethylhexyl) Phthalate	Yes	No	--	--	--	--
TPH							
68334-30-5	TPH as Diesel	Yes	Yes	--	--	--	--
PHCG	TPH as Gasoline	Yes	Yes	--	--	--	--
TPHMOIL	TPH as Motor Oil	Yes	Yes	--	--	--	--
VOCs							
79-34-5	1,1,2,2-Tetrachloroethane	Yes	No	--	--	Yes	No
79-00-5	1,1,2-Trichloroethane	No	No	--	--	Yes	No
75-34-3	1,1-Dichloroethane	--	--	--	--	Yes	No
96-18-4	1,2,3-Trichloropropane	Yes	No	--	--	--	--
120-82-1	1,2,4-Trichlorobenzene	No	No	Yes	No	--	--
95-63-6	1,2,4-Trimethylbenzene	Yes	Yes	Yes	Yes	Yes	Yes
107-06-2	1,2-Dichloroethane	Yes	No	Yes	No	Yes	No
78-87-5	1,2-Dichloropropane	Yes	No	Yes	No	--	--
108-67-8	1,3,5-Trimethylbenzene	Yes	Yes	Yes	Yes	Yes	Yes
106-99-0	1,3-Butadiene	--	--	Yes	No	--	--
106-46-7	1,4-Dichlorobenzene	Yes	No	Yes	No	Yes	No
123-91-1	1,4-Dioxane	--	--	Yes	No	--	--
540-84-1	2,2,4-Trimethylpentane	--	--	Yes	No	No	No
78-93-3	2-Butanone (Methyl Ethyl Ketone)	No	No	No	No	Yes	No

Table 2-1
Summary of Constituents of Concern

CAS Number	Chemical[1]	Soil		Soil Vapor, Sub-Slab		Soil Vapor, Non-Sub-Slab	
		COC	Site-Related COC[1]	COC	Site-Related COC[1]	COC	Site-Related COC[1]
591-78-6	2-Hexanone	No	No	Yes	No	Yes	No
622-96-8	4-Ethyltoluene	--	--	No	Yes	Yes	Yes
71-43-2	Benzene	Yes	Yes	Yes	Yes	Yes	Yes
75-27-4	Bromodichloromethane	Yes	No	Yes	No	Yes	No
74-83-9	Bromomethane	Yes	No	Yes	No	No	No
75-15-0	Carbon Disulfide	No	No	No	No	Yes	No
56-23-5	Carbon Tetrachloride	--	--	Yes	No	--	--
67-66-3	Chloroform	No	No	Yes	No	Yes	No
110-82-7	Cyclohexane	--	--	No	Yes	Yes	Yes
124-48-1	Dibromochloromethane	No	No	Yes	No	--	--
156-59-2	Dichloroethene, cis-1,2-	Yes	No	No	No	Yes	No
156-60-5	Dichloroethene, trans-1,2-	--	--	No	No	Yes	No
10061-02-6	Dichloropropene, trans-1,3-	--	--	Yes	No	Yes	No
64-17-5	Ethanol	No	No	No	No	Yes	No
100-41-4	Ethylbenzene	Yes	Yes	Yes	Yes	Yes	Yes
142-82-5	Heptane	--	--	No	Yes	Yes	Yes
87-68-3	Hexachloro-1,3-Butadiene	--	--	--	--	Yes	No
110-54-3	Hexane	--	--	No	Yes	Yes	Yes
67-63-0	Isopropanol	--	--	No	No	Yes	No
98-82-8	Isopropylbenzene (cumene)	No	No	No	Yes	Yes	Yes
75-09-2	Methylene Chloride	Yes	No	Yes	No	Yes	No
1634-04-4	Methyl-tert-Butyl Ether	No	No	Yes	No	Yes	No
91-20-3	Naphthalene	Yes	Yes	Yes	Yes	Yes	Yes
103-65-1	Propylbenzene	No	No	No	Yes	Yes	Yes
75-65-0	tert-Butyl Alcohol (TBA)	Yes	No	--	--	Yes	No
127-18-4	Tetrachloroethene	Yes	No	Yes	No	Yes	No
109-99-9	Tetrahydrofuran	--	--	Yes	No	No	No
108-88-3	Toluene	Yes[4]	Yes	Yes[4]	Yes	Yes[4]	Yes
79-01-6	Trichloroethene	Yes	No	Yes	No	Yes	No
75-01-4	Vinyl Chloride	Yes	No	Yes	No	Yes	No
95-47-6	o-Xylene	Yes[4]	Yes	Yes[4]	Yes	Yes[4]	Yes
1330-20-7-1	p/m-Xylene	Yes[4]	Yes	Yes[4]	Yes	Yes[4]	Yes
1330-20-7	Xylenes, Total	Yes[4]	Yes	Yes[4]	Yes	Yes[4]	Yes

Notes:

-- not available or not applicable

COC: Constituent of Concern

[1] Site-Related COCs may be related to Site activities associated with crude oil storage prior to redevelopment.

[2] Additional background analysis (one-sample proportion test) indicated this metal to be within background for all properties.

[3] Due to change in oral cancer assessment not reflected in RBSLs from HHSRE Work Plan, hexavalent chromium included as a COC.

[4] Although not selected as COCs through the screening process, the RWQCB has requested these VOCs to be evaluated as COCs.

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Table 3-1
Site-Specific Cleanup Goals For Soil

CAS Number	Constituents of Concern	$SSCG_{soil\text{-}GW}$ [1] (mg/kg)	(BTV) [2] (mg/kg)	Soil Site-Specific Cleanup Goals (mg/kg)					
				Onsite Resident				Construction and Utility Maintenance Worker	
				EF = 350 d/y		EF = 4 d/y			
				SSCG (mg/kg)	Basis	SSCG (mg/kg)	Basis	SSCG (mg/kg)	Basis
	Inorganics								
7440-36-0	Antimony	2.7E-01	7.4E-01	3.1E+01	nc	2.7E+03	nc	3.1E+03	nc
7440-38-2	Arsenic	--	1.2E+01	6.1E-02	c	5.4E+00	c	1.5E+01	c
7440-43-9	Cadmium	--	3.8E+00	7.0E+01	nc	6.2E+03	nc	2.4E+02	c
18540-29-9	Chromium VI	--	--	1.3E+00	c	1.1E+02	c	6.7E+00	c
7440-48-4	Cobalt	--	1.1E+01	2.3E+01	nc	2.1E+03	nc	1.1E+02	c
7440-50-8	Copper	--	5.9E+01	3.1E+03	nc	2.7E+05	nc*	3.1E+05	nc*
7439-92-1	Lead	--	6.1E+01	8.0E+01 [3]	--	8.2E+02 [4]	--	8.2E+02 [5]	--
7440-28-0	Thallium	1.4E-01	2.3E-01	7.8E-01	nc	6.8E+01	nc	7.7E+01	nc
7440-62-2	Vanadium	--	4.6E+01	3.9E+02	nc	3.4E+04	nc	3.3E+03	nc
7440-66-6	Zinc	--	2.9E+02	2.3E+04	nc	2.1E+06	nc*	2.3E+06	nc*
	PAHs								
56-55-3	Benz[a]anthracene	--	--	1.6E+00	c	1.4E+02	c	2.6E+02	c
50-32-8	Benzo[a]pyrene	--	9.0E-01	1.6E-01	c	1.4E+01	c	2.6E+01	c
205-99-2	Benzo[b]fluoranthene	--	--	1.6E+00	c	1.4E+02	c	2.6E+02	c
207-08-9	Benzo[k]fluoranthene	--	--	1.6E+00	c	1.4E+02	c	2.6E+02	c
218-01-9	Chrysene	--	--	1.6E+01	c	1.4E+03	c	2.6E+03	c
53-70-3	Dibenz[a,h]anthracene	--	--	1.1E-01	c	9.7E+00	c	1.9E+01	c
193-39-5	Indeno[1,2,3-cd]pyrene	--	--	1.6E+00	c	1.4E+02	c	2.6E+02	c
90-12-0	Methylnaphthalene, 1-	--	--	1.6E+01	c	1.4E+03	c	2.7E+03	c
91-57-6	Methylnaphthalene, 2-	--	--	2.3E+02	nc	2.0E+04	nc	1.1E+04	nc
91-20-3	Naphthalene	1.4E+01	--	4.0E+00	c	3.5E+02	c	3.9E+01	c
129-00-0	Pyrene	--	--	1.7E+03	nc	1.5E+05	nc*	6.7E+04	nc
	TPH								
	TPHg	117	--	7.6E+02	nc	6.6E+04	nc*	8.6E+02	nc
	TPHd	625	--	1.3E+03	nc	1.1E+05	nc*	1.9E+03	nc
	TPHmo	10,000	--	3.3E+03	nc	2.9E+05	nc*	1.6E+05	nc*
	SVOCs								
121-14-2	2,4-Dinitrotoluene	--	--	1.6E+00	c	1.4E+02	c	2.8E+02	c
117-81-7	Bis(2-Ethylhexyl) Phthalate	--	--	3.5E+01	c	3.0E+03	c	6.4E+03	c
	VOCs								
79-34-5	1,1,2,2-Tetrachloroethane	--	--	4.7E-01	c	4.1E+01	c	5.7E+00	c
96-18-4	1,2,3-Trichloropropane	4.2E-06	--	2.1E-02	c	1.9E+00	c	2.0E+00	nc
95-63-6	1,2,4-Trimethylbenzene	--	--	8.3E+01	nc	7.2E+03	nc	7.5E+01	nc
107-06-2	1,2-Dichloroethane	3.2E-04	--	--		--		--	
156-59-2	cis-1,2-Dichloroethene	3.9E-03	--	--		--		--	

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Table 3-1
Site-Specific Cleanup Goals For Soil

CAS Number	Constituents of Concern	$SSCG_{soil-GW}$ [1] (mg/kg)	(BTV) [2] (mg/kg)	Soil Site-Specific Cleanup Goals (mg/kg)					
				Onsite Resident				Construction and Utility Maintenance Worker	
				EF = 350 d/y		EF = 4 d/y			
				SSCG (mg/kg)	Basis	SSCG (mg/kg)	Basis	SSCG (mg/kg)	Basis
78-87-5	1,2-Dichloropropane	--	--	8.3E-01	c	7.2E+01	c	8.5E+00	c
108-67-8	1,3,5-Trimethylbenzene	--	--	8.5E+01	nc	7.4E+03	nc	7.7E+01	nc
106-46-7	1,4-Dichlorobenzene	1.2E-02	--	2.8E+00	c	2.4E+02	c	2.8E+01	c
71-43-2	Benzene	2.1E-02	--	2.2E-01	c	1.9E+01	c	2.2E+00	c
75-27-4	Bromodichloromethane	--	--	4.9E-01	c	4.2E+01	c	5.3E+00	c
74-83-9	Bromomethane	--	--	8.8E+00	nc	7.7E+02	nc	7.8E+00	nc
100-41-4	Ethylbenzene	--	--	4.8E+00	c	4.2E+02	c	5.1E+01	c
75-09-2	Methylene chloride	--	--	5.3E+00	c	4.7E+02	c	5.9E+01	c
75-65-0	tert-Butyl Alcohol	7.9E-03	--	--		--		--	
127-18-4	Tetrachloroethene	5.8E-03	--	5.5E-01	c	4.9E+01	c	1.0E+01	c
108-88-3	Toluene	--	--	4.8E+03	nc	4.2E+05	nc*	1.6E+04	nc
79-01-6	Trichloroethene	3.2E-03	--	1.2E+00	c	1.0E+02	c	5.5E+00	nc
75-01-4	Vinyl chloride	3.2E-04	--	3.2E-02	c	2.8E+00	c	3.1E-01	c
1330-20-7	Xylene, total	--	--	5.6E+02	nc	4.9E+04	nc	4.7E+02	nc

Notes:

" -- " not applicable or not available

EF = exposure frequency; d/y = days per year

TPHg = Total Petroleum Hydrocarbons- gasoline range

TPHd = Total Petroleum Hydrocarbons- diesel range

TPHmo = Total Petroleum Hydrocarbons- motor oil range

nc = SSCG based on noncancer effects; c = SSCG based on cancer effects

* Values are above Csat, 1E+05 or Cres

[1] A $SSCG_{soil-GW}$ value was only listed for those COCs identified for potential soil leaching to groundwater. These $SSCG_{soil-GW}$ are from the January 23, 2014 letter from the Regional Board on the Revised SSCG Report as corrected in the May 29, 2014 letter from the Regional Board for benzene and TPH-mo.

[2] To evaluate potential human health exposures, the higher value between the health-based SSCG and Background Threshold Value (BTV) will be selected as the cleanup goal. To evaluate potential leaching to groundwater, the higher between $SSCG_{soil-GW}$ and BTV will be will be selected as the cleanup goal.

[3] California Environmental Protection Agency. 2009. Revised California Human Health Screening Levels (CHHSL) for Lead. September 2009.

[4] Based on USEPA adult lead model, similar parameters used for the residential CHHSL, and a lower exposure frequency.

[5] Based on USEPA adult lead model, similar parameters used for the industrial worker CHHSL, and a lower exposure frequency.

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Table 3-2
Site-Specific Cleanup Goals For Sub-Slab and Soil Vapor

CAS Number	Constituents of Concern	Odor-Based SSCG[1] (µg/m³)	Sub-Slab and Soil Vapor — Onsite Resident SSCG (µg/m³)	Basis	Soil Vapor — Construction and Utility Maintenance Worker SSCG (µg/m³)	Basis
79-34-5	1,1,2,2-Tetrachloroethane	5.2E+06	2.1E+01	c	1.2E+05	c
79-00-5	1,1,2-Trichloroethane	--	7.5E+01	c	1.0E+05	nc
75-34-3	1,1-Dichloroethane	6.3E+07	7.6E+02	c	2.5E+07	c
120-82-1	1,2,4-Trichlorobenzene	1.1E+07	1.0E+03	nc	3.9E+05	nc
95-63-6	1,2,4-Trimethylbenzene	--	3.7E+03	nc	2.3E+06	nc
107-06-2	1,2-Dichloroethane	1.2E+06	5.9E+01	c	8.5E+05	c
78-87-5	1,2-Dichloropropane	6.0E+05	1.2E+02	c	2.5E+06	c
108-67-8	1,3,5-Trimethylbenzene	--	3.7E+03	nc	2.3E+06	nc
106-99-0	1,3-Butadiene	--	7.2E+00	c	3.0E+05	c
106-46-7	1,4-Dichlorobenzene	5.5E+05	1.1E+02	c	7.2E+05	c
123-91-1	1,4-Dioxane	3.1E+08	1.6E+02	c	1.6E+05	c
540-84-1	2,2,4-Trimethylpentane	--	5.2E+05	nc	6.5E+08	nc
591-78-6	2-Hexanone	--	1.6E+04	nc	7.9E+06	nc
622-96-8	4-Ethyltoluene	--	5.2E+04	nc	2.5E+07	nc
71-43-2	Benzene	2.4E+06	4.2E+01	c	1.0E+06	c
75-27-4	Bromodichloromethane	5.5E+09	3.3E+01	c	7.8E+05	c
74-83-9	Bromomethane	4.0E+07	2.6E+03	nc	9.5E+06	nc
75-15-0	Carbon disulfide	--	3.7E+05	nc	1.4E+09	nc
56-23-5	Carbon tetrachloride	3.2E+07	2.9E+01	c	1.1E+06	c
67-66-3	Chloroform	2.1E+08	2.3E+02	c	4.9E+06	c
110-82-7	Cyclohexane	--	3.1E+06	nc	1.8E+10	nc
124-48-1	Dibromochloromethane	--	4.5E+01	c	8.8E+05	c
156-59-2	Dichloroethene, cis-1,2-	3.4E+07	3.7E+03	nc	8.3E+06	nc
156-60-5	Dichloroethene, trans-1,2-	3.4E+07	3.1E+04	nc	9.3E+07	nc
10061-02-6	Dichloropropene, trans-1,3-	2.1E+06	7.6E+01	c	3.9E+06	c
64-17-5	Ethanol	--	2.1E+06	nc	1.9E+08	nc
100-41-4	Ethylbenzene	1.0E+06	4.9E+02	c	7.0E+06	c
142-82-5	Heptane	--	3.7E+05	nc	2.3E+09	nc
87-68-3	Hexachloro-1,3-butadiene	6.0E+06	5.5E+01	c	8.0E+04	c
110-54-3	Hexane	--	3.7E+05	nc	1.7E+09	nc
67-63-0	Isopropanol	--	3.7E+06	nc	5.7E+08	nc
98-82-8	Isopropylbenzene (cumene)	--	2.1E+05	nc	1.5E+09	nc
78-93-3	Methyl ethyl ketone (2-butanone)	1.6E+07	2.6E+06	nc	1.1E+09	nc
75-09-2	Methylene chloride	2.8E+08	1.2E+03	c	2.8E+07	c
1634-04-4	Methyl-tert-butyl ether	2.7E+05	4.7E+03	c	6.5E+07	c

Table 3-2
Site-Specific Cleanup Goals For Sub-Slab and Soil Vapor

CAS Number	Constituents of Concern	Odor-Based SSCG[1] (µg/m³)	Sub-Slab and Soil Vapor: Onsite Resident		Soil Vapor: Construction and Utility Maintenance Worker	
			SSCG (µg/m³)	Basis	SSCG (µg/m³)	Basis
91-20-3	Naphthalene	2.2E+05	3.6E+01	c	6.3E+04	c
103-65-1	Propylbenzene	--	5.2E+05	nc	6.6E+08	nc
75-65-0	tert-Butyl Alcohol (TBA)	--	5.5E+05	nc	2.6E+08	nc
127-18-4	Tetrachloroethene	1.6E+07	2.1E+02	c	6.6E+06	c
109-99-9	Tetrahydrofuran	--	1.0E+06	nc	4.9E+08	nc
108-88-3	Toluene	1.5E+07	2.6E+06	nc	3.7E+09	nc
79-01-6	Trichloroethene	6.8E+08	2.2E+02	c	2.0E+06	nc
75-01-4	Vinyl chloride	3.9E+08	1.6E+01	c	8.3E+05	c
1330-20-7	Xylene, total	2.2E+05	5.2E+04	nc	5.9E+07	nc
	TPH					
	Aliphatic: C5-C8	--	3.7E+05	nc	1.2E+09	nc
	Aliphatic: C9-C18	--	1.6E+05	nc	1.2E+08	nc
	Aliphatic: C19-C32	--	--	--	--	--
	Aromatic: C6-C8	--	--	--	--	--
	Aromatic: C9-C16	--	2.6E+04	nc	6.7E+06	nc
	Aromatic: C17-C32	--	--	--	--	--
	TPHg	5.0E+04	7.2E+04	nc	2.2E+07	nc
	TPHd	5.0E+05	8.1E+04	nc	2.3E+07	nc
	TPHmo	--	--	--	--	--

Notes:

" -- " not applicable or not available

[1] Odor-based SSCGs for soil vapor based on SFRWCQB 2013 ESL as directed by RWQCB (RWQCB, 2014a)

nc = SSCG based on noncancer effects; c = SSCG based on cancer effects

Geosyntec consultants

Table 3-3
Property Addresses For Consideration in Remedial Planning

Address	Shallow Excavation	SVE/Bioventing		Targeted Excavation for >5 to ≤10 ft bgs Depth Interval			Sub-Slab Soil Vapor Mitigation
	Exceeds HH Criteria or Leaching to GW SSCGs < 5 ft bgs	Exceeds HH Criteria or Leaching to GW SSCGs >5 to ≤10 ft bgs	Exceeds in either ≤ 5ft or >5 to ≤10 ft bgs depth interval	Front Yard	Back Yard	Both Yards	Identified in HHRA based on > 1 E-6 Risk Level
24401 MARBELLA AVE							
24402 NEPTUNE AVE	X	X	X		X		
24402 PANAMA AVE	X		X				
24402 RAVENNA AVE	X	X	X		X		
24403 NEPTUNE AVE	X	X	X	X	X	X	
24403 RAVENNA AVE		X	X				
24405 MARBELLA AVE							
24406 MARBELLA AVE	X	X	X		X		
24406 NEPTUNE AVE		X	X				X
24406 PANAMA AVE	X		X				
24406 RAVENNA AVE	X	X	X				
24409 NEPTUNE AVE	X	X	X	X	X	X	
24409 RAVENNA AVE		X	X				
24410 PANAMA AVE							
24411 MARBELLA AVE	X		X				
24411 PANAMA AVE	X	X	X		X		
24412 MARBELLA AVE	X	X	X	X	X	X	X
24412 RAVENNA AVE	X	X	X				
24413 NEPTUNE AVE	X	X	X	X	X	X	
24413 RAVENNA AVE		X	X				
24416 MARBELLA AVE	X	X	X	X	X	X	
24416 NEPTUNE AVE	X		X				
24416 PANAMA AVE							
24416 RAVENNA AVE	X	X	X				X
24417 MARBELLA AVE							
24417 PANAMA AVE		X	X				
24419 NEPTUNE AVE	X	X	X	X	X	X	
24419 RAVENNA AVE		X	X				
24420 PANAMA AVE	X		X				
24421 PANAMA AVE	X	X	X	X			
24422 MARBELLA AVE	X	X	X				
24422 NEPTUNE AVE		X	X				
24422 RAVENNA AVE	X	X	X				
24423 MARBELLA AVE							
24423 NEPTUNE AVE	X	X	X	X	X	X	X
24423 RAVENNA AVE	X	X	X				
24426 MARBELLA AVE	X	X	X	X	X	X	
24426 NEPTUNE AVE		X	X				
24426 PANAMA AVE	X		X				
24426 RAVENNA AVE	X		X		X		
24427 MARBELLA AVE							
24427 PANAMA AVE		X	X				
24429 NEPTUNE AVE	X	X	X	X	X	X	X
24429 RAVENNA AVE	X	X	X				
24430 PANAMA AVE							
24431 PANAMA AVE	X	X	X				
24432 MARBELLA AVE	X	X	X		X		
24433 MARBELLA AVE	X		X				X
24436 PANAMA AVE	X		X				

Table 3-3
Property Addresses For Consideration in Remedial Planning

Address	Shallow Excavation	SVE/Bioventing		Targeted Excavation for >5 to ≤10 ft bgs Depth Interval			Sub-Slab Soil Vapor Mitigation
	Exceeds HH Criteria or Leaching to GW SSCGs < 5 ft bgs	Exceeds HH Criteria or Leaching to GW SSCGs >5 to ≤10 ft bgs	Exceeds in either ≤ 5ft or >5 to ≤10 ft bgs depth interval	Front Yard	Back Yard	Both Yards	Identified in HHRA based on > 1 E-6 Risk Level
24502 MARBELLA AVE	X	X	X				
24502 NEPTUNE AVE		X	X				
24502 PANAMA AVE							
24502 RAVENNA AVE	X	X	X		X		
24503 MARBELLA AVE							
24503 NEPTUNE AVE	X	X	X	X	X	X	
24503 PANAMA AVE	X	X	X				
24503 RAVENNA AVE		X	X				
24506 MARBELLA AVE	X	X	X	X			X
24507 MARBELLA AVE							
24508 NEPTUNE AVE	X	X	X		X		
24508 PANAMA AVE							X
24508 RAVENNA AVE	X	X	X	X			
24509 NEPTUNE AVE	X	X	X				
24509 PANAMA AVE	X	X	X	X	X	X	
24509 RAVENNA AVE	X	X	X	X			
24512 MARBELLA AVE	X	X	X	X	X	X	
24512 NEPTUNE AVE	X	X	X		X		
24512 PANAMA AVE							
24512 RAVENNA AVE	X	X	X	X			
24513 NEPTUNE AVE		X	X				
24513 PANAMA AVE	X	X	X		X		
24513 RAVENNA AVE		X	X				X
24516 MARBELLA AVE	X	X	X		X		
24517 MARBELLA AVE	X		X				
24518 NEPTUNE AVE	X	X	X	X			
24518 PANAMA AVE							
24518 RAVENNA AVE	X	X	X	X	X	X	
24519 NEPTUNE AVE	X	X	X				
24519 PANAMA AVE	X	X	X		X		
24522 MARBELLA AVE	X	X	X				
24522 NEPTUNE AVE	X	X	X				
24522 PANAMA AVE							
24522 RAVENNA AVE	X	X	X				
24523 MARBELLA AVE							
24523 NEPTUNE AVE	X	X	X		X		
24523 RAVENNA AVE	X	X	X	X			
24526 MARBELLA AVE	X	X	X		X		
24528 NEPTUNE AVE	X	X	X				
24528 PANAMA AVE							
24529 NEPTUNE AVE	X	X	X		X		
24529 PANAMA AVE							
24529 RAVENNA AVE	X	X	X				
24532 MARBELLA AVE	X	X	X		X		
24532 NEPTUNE AVE							
24532 PANAMA AVE	X	X	X				
24532 RAVENNA AVE							
24533 MARBELLA AVE							
24533 PANAMA AVE	X		X				

Table 3-3
Property Addresses For Consideration in Remedial Planning

Address	Shallow Excavation	SVE/Bioventing		Targeted Excavation for >5 to ≤10 ft bgs Depth Interval			Sub-Slab Soil Vapor Mitigation
	Exceeds HH Criteria or Leaching to GW SSCGs < 5 ft bgs	Exceeds HH Criteria or Leaching to GW SSCGs >5 to ≤10 ft bgs	Exceeds in either ≤ 5ft or >5 to ≤10 ft bgs depth interval	Front Yard	Back Yard	Both Yards	Identified in HHRA based on > 1 E-6 Risk Level
24533 RAVENNA AVE							
24602 MARBELLA AVE		X	X				
24602 NEPTUNE AVE							
24602 PANAMA AVE		X	X				
24602 RAVENNA AVE							
24603 MARBELLA AVE	X		X				X
24603 NEPTUNE AVE	X	X	X				
24603 PANAMA AVE	X		X				
24603 RAVENNA AVE	X	X	X				
24606 MARBELLA AVE	X	X	X		X		
24607 MARBELLA AVE		X	X				
24608 NEPTUNE AVE	X	X	X				
24608 PANAMA AVE	X	X	X				
24608 RAVENNA AVE	X	X	X				
24609 NEPTUNE AVE	X	X	X	X	X	X	
24609 PANAMA AVE	X	X	X				X
24609 RAVENNA AVE	X		X				
24612 MARBELLA AVE	X	X	X	X	X	X	
24612 NEPTUNE AVE	X	X	X	X	X	X	
24612 PANAMA AVE	X	X	X				
24612 RAVENNA AVE	X		X				
24613 MARBELLA AVE[a]	X						
24613 NEPTUNE AVE	X	X	X	X	X	X	
24613 PANAMA AVE	X	X	X				X
24613 RAVENNA AVE	X	X	X				
24616 MARBELLA AVE	X	X	X	X	X	X	
24617 MARBELLA AVE	X	X	X				
24618 NEPTUNE AVE	X	X	X	X	X	X	
24618 PANAMA AVE	X	X	X				
24618 RAVENNA AVE	X		X				
24619 NEPTUNE AVE	X	X	X	X	X	X	
24619 PANAMA AVE	X	X	X				
24619 RAVENNA AVE		X	X				
24622 MARBELLA AVE	X	X	X	X	X	X	
24622 NEPTUNE AVE	X	X	X	X	X	X	
24623 MARBELLA AVE	X	X	X				X
24623 NEPTUNE AVE	X	X	X	X	X	X	
24627 MARBELLA AVE	X	X	X	X			
24628 MARBELLA AVE	X	X	X		X		
24628 NEPTUNE AVE		X	X				
24629 NEPTUNE AVE	X	X	X	X	X	X	X
24632 NEPTUNE AVE[b]	X	X	X	X	X	X	X
24633 MARBELLA AVE	X		X				
24700 MARBELLA AVE	X	X	X	X			
24700 RAVENNA AVE							
24702 NEPTUNE AVE	X	X	X	X	X	X	
24702 PANAMA AVE	X	X	X				
24703 MARBELLA AVE	X		X				
24703 NEPTUNE AVE	X	X	X	X			

Table 3-3
Property Addresses For Consideration in Remedial Planning

Address	Shallow Excavation	SVE/Bioventing		Targeted Excavation for >5 to ≤10 ft bgs Depth Interval			Sub-Slab Soil Vapor Mitigation
	Exceeds HH Criteria or Leaching to GW SSCGs < 5 ft bgs	Exceeds HH Criteria or Leaching to GW SSCGs >5 to ≤10 ft bgs	Exceeds in either ≤ 5ft or >5 to ≤10 ft bgs depth interval	Front Yard	Back Yard	Both Yards	Identified in HHRA based on > 1 E-6 Risk Level
24703 PANAMA AVE	X	X	X				
24703 RAVENNA AVE	X	X	X		X		
24706 MARBELLA AVE	X	X	X	X			
24706 RAVENNA AVE	X		X				
24707 MARBELLA AVE							
24708 PANAMA AVE	X	X	X				
24709 NEPTUNE AVE	X	X	X		X		X
24709 PANAMA AVE	X	X	X		X		
24709 RAVENNA AVE	X	X	X		X		
24710 MARBELLA AVE	X	X	X		X		
24712 NEPTUNE AVE	X	X	X	X	X	X	X
24712 PANAMA AVE	X	X	X				
24712 RAVENNA AVE	X		X				
24713 MARBELLA AVE							
24713 PANAMA AVE	X	X	X				
24713 RAVENNA AVE	X	X	X		X		
24715 NEPTUNE AVE	X	X	X	X	X	X	
24716 MARBELLA AVE	X	X	X				
24716 RAVENNA AVE	X		X				
24717 MARBELLA AVE	X		X				
24718 NEPTUNE AVE	X	X	X	X			
24718 PANAMA AVE	X	X	X				
24719 NEPTUNE AVE	X	X	X	X			
24719 PANAMA AVE	X	X	X				
24719 RAVENNA AVE	X	X	X		X		
24722 MARBELLA AVE	X		X				
24722 NEPTUNE AVE							X
24722 PANAMA AVE	X		X				
24722 RAVENNA AVE	X		X				
24723 MARBELLA AVE	X		X				X
24723 RAVENNA AVE	X	X	X				
24725 NEPTUNE AVE							
24726 MARBELLA AVE							
24726 RAVENNA AVE	X		X				
24727 MARBELLA AVE	X		X				
24728 NEPTUNE AVE	X	X	X				
24728 PANAMA AVE	X	X	X				
24729 NEPTUNE AVE	X		X				
24729 PANAMA AVE							
24729 RAVENNA AVE							
24732 MARBELLA AVE	X		X				
24732 NEPTUNE AVE	X	X	X		X		
24732 PANAMA AVE							
24732 RAVENNA AVE	X		X				
24733 MARBELLA AVE	X		X				
24733 PANAMA AVE	X		X				
24733 RAVENNA AVE	X	X	X				
24735 NEPTUNE AVE	X		X				
24736 MARBELLA AVE							

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Table 3-3
Property Addresses For Consideration in Remedial Planning

Address	Shallow Excavation	SVE/Bioventing		Targeted Excavation for >5 to ≤10 ft bgs Depth Interval			Sub-Slab Soil Vapor Mitigation
	Exceeds HH Criteria or Leaching to GW SSCGs < 5 ft bgs	Exceeds HH Criteria or Leaching to GW SSCGs >5 to ≤10 ft bgs	Exceeds in either ≤ 5ft or >5 to ≤10 ft bgs depth interval	Front Yard	Back Yard	Both Yards	Identified in HHRA based on > 1 E-6 Risk Level
24736 RAVENNA AVE	X	X	X	X			
24737 MARBELLA AVE	X	X	X				
24738 NEPTUNE AVE	X	X	X	X	X	X	X
24738 PANAMA AVE	X		X				
24739 NEPTUNE AVE	X		X				
24739 PANAMA AVE	X	X	X				
24739 RAVENNA AVE	X	X	X	X	X	X	
24740 MARBELLA AVE	X		X				
24741 MARBELLA AVE							X
24743 RAVENNA AVE	X	X	X	X	X	X	
24744 MARBELLA AVE	X		X				X
24748 RAVENNA AVE	X	X	X				
24749 RAVENNA AVE	X	X	X		X		X
24752 RAVENNA AVE	X	X	X				
24802 PANAMA AVE	X		X				
24803 NEPTUNE AVE	X		X				
24803 PANAMA AVE	X	X	X				
24808 PANAMA AVE	X		X				
24809 NEPTUNE AVE	X	X	X				
24809 PANAMA AVE	X	X	X	X	X	X	
24812 PANAMA AVE	X		X				
24813 PANAMA AVE	X	X	X				
24815 NEPTUNE AVE	X	X	X				
24818 PANAMA AVE	X		X				
24819 PANAMA AVE	X	X	X		X		
24822 PANAMA AVE	X	X	X				
24823 PANAMA AVE	X	X	X	X			
24825 NEPTUNE AVE							
24828 PANAMA AVE	X	X	X				
24829 PANAMA AVE	X	X	X				
24832 PANAMA AVE	X	X	X				
24833 PANAMA AVE	X	X	X				
24838 PANAMA AVE	X		X				
24904 NEPTUNE AVE		X	X				
24912 NEPTUNE AVE		X	X				
301 244TH ST							
305 244TH ST	X	X	X				
311 244TH ST	X	X	X				
317 244TH ST	X		X				X
321 244TH ST[a]	X						
327 244TH ST							
331 244TH ST[a]	X						
337 244TH ST							
341 244TH ST							
344 249TH ST	X		X				
345 249TH ST	X	X	X				
347 244TH ST							
348 248TH ST	X	X	X	X			X
348 249TH ST	X	X	X				

Table 3-3
Property Addresses For Consideration in Remedial Planning

Address	Shallow Excavation	SVE/Bioventing		Targeted Excavation for >5 to ≤10 ft bgs Depth Interval			Sub-Slab Soil Vapor Mitigation
	Exceeds HH Criteria or Leaching to GW SSCGs < 5 ft bgs	Exceeds HH Criteria or Leaching to GW SSCGs >5 to ≤10 ft bgs	Exceeds in either ≤ 5ft or >5 to ≤10 ft bgs depth interval	Front Yard	Back Yard	Both Yards	Identified in HHRA based on > 1 E-6 Risk Level
351 244TH ST	X		X				
352 249TH ST		X	X				X
353 249TH ST	X	X	X				
354 248TH ST	X	X	X	X	X	X	
357 244TH ST							
357 249TH ST		X	X				
358 249TH ST	X		X				
360 248TH ST	X	X	X	X			
361 244TH ST							
362 249TH ST							
363 249TH ST	X	X	X	X			
364 248TH ST	X	X	X				
367 244TH ST	X		X				
367 249TH ST	X	X	X				
368 249TH ST	X	X	X				
373 249TH ST	X	X	X	X			
374 248TH ST	X	X	X		X		
374 249TH ST	X	X	X				
377 244TH ST							
377 249TH ST	X	X	X	X			
378 249TH ST	X	X	X				X
383 249TH ST	X	X	X				X
402 249TH ST	X		X				
408 249TH ST							
412 249TH ST	X	X	X				

[a] = Property exceeds SSCGs in the > 5 to ≤10 feet bgs interval, but only for metals above background, therefore no SVE/bioventing is proposed.
[b] = Property not identified in HHRA based on > 1 E-6 risk level, but slightly exceeds RAO for methane.
GW = groundwater
HH = Human Health
RA = Risk Assessment
SSCG = Site-Specific Cleanup Goal
SVE = Soil Vapor Extraction

"X" - Property Selected For Remediation based on results of Human Health Risk Assessment or additional considerations such as targeted mass removal (excavation at some properties > 5 to ≤10 feet bgs) or risk management considerations (subslab depressurization systems)

Table 4-1
Screening of Remedial Technologies

TECHNOLOGY	DESCRIPTION	SCREENING CRITERIA			COMMENTS
		EFFECTIVENESS	IMPLEMENTABILITY	COST	
Sub-Slab Vapor Intrusion Mitigation	Install subsurface barriers and/or vapor control systems to mitigate soil vapor migration into buildings.	Effective for VOCs.	Sub-slab depressurization systems are implementable at existing building locations.	Low-to-moderate capital to install sub-slab depressurization system; low-to-moderate O&M.	Installation of sub-slab depressurization systems is retained for consideration in remedial alternatives.
Capping Portions of the Site	Mitigate contact with impacted soils; mitigate rainwater infiltration; reduce vapor migration to surface by constructing a low permeability cover or "cap" over the areas of impacted soils.	Effective for all COCs.	Implementable over portions of the Site. May require restriction on future land use.	Moderate capital, low O&M cost.	Retained for consideration in remedial alternatives. Could possibly be used in conjunction with excavation.
Removal of All Site Features	The removal of all Site features would include the removal of all houses, landscape, hardscape, roads, and utilities.	The removal of all site features in order to facilitate the use of other remedial technologies (e.g., excavation or capping) could be effective at the Site.	Very difficult to implement. Every resident within the Site would have to agree to relocate and all 285 houses would be razed. If some homeowners declined to move, the presence of some residents would make it untenable to remove all of the surrounding homes, streets and utilities. Permitting would be very difficult to allow this work to move forward.	Very high cost.	Retained for consideration in remedial alternatives.
Institutional Controls	Rely upon City of Carson Building Code provisions requiring permitting for excavations 3 feet bgs or deeper. Establish a process whereby Shell is notified if a resident applies for a permit to excavate so that arrangements can be made for sampling and proper handling of impacted soils that may be present.	Effective for all COCs.	Implementable; building code provisions already are in place. May be implemented in combination with other technologies.	Minimal cost.	Retained for consideration in remedial alternatives.
Excavation: *Selective Excavation*	Excavate impacted soils around existing structures. Backfill excavation with imported clean soil. A wide range of excavation options is available, including different areas of excavation and different depths.	Effective for all COCs.	Implementability dependent on depth. Volume of excavated soil, disruption to community, loss of residential tax base, sustainability concerns all factor into implementability. Potential major difficulties due to traffic and dust. Major difficulties due to VOC emissions if excavation is performed prior to remediation of VOCs. Excavation to 2 or 3 feet would be more easily implementable than excavations to 5 or 10 feet; concerns and difficulties rise significantly with deeper excavations.	Moderate-to-exceptionally high capital, depending upon depth. Minimal O&M.	Retained for consideration in remedial alternatives because of effectiveness in removing impacted materials and interrupting the human health exposure pathway.
Excavation: *Targeted Excavation*	Additionally excavate deeper impacted soils around existing structures in targeted areas where the potential exists for substantial hydrocarbon mass removal at greater depths. Backfill excavation with imported clean soil.	Effective for all COCs.	Implementability more difficult due to greater depth; concerns and difficulties rise significantly with deeper excavations.	Moderate capital for additional targeted excavation. Minimal O&M.	Retained for consideration in remedial alternatives because of effectiveness in removing the most-impacted materials and interrupting the leaching to groundwater pathway.

Table 4-1
Screening of Remedial Technologies

TECHNOLOGY	DESCRIPTION	SCREENING CRITERIA			COMMENTS
		EFFECTIVENESS	IMPLEMENTABILITY	COST	
Excavation: *Lifting and Cribbing of Houses to Assist in Excavation*	Cribbing would take place outside of the house footprint to allow excavation below. It would include cutting and capping utilities; demolition of drywall, cabinets, toilets, and tub/showers from ground level to 4 feet high; demolition of fireplaces; installation of beams that attach to every wall; unbolting walls from foundation; lifting house and cribbing to 4 feet high; excavating impacted soils; backfilling with clean soil; forming and pouring a new foundation; placing the house back down on new foundation and attaching to foundation; removing cribbing materials; restoring interior walls, cabinets, toilets, tub/showers; replacing fireplaces; and reconnecting utilities.	Ineffective because of lack of clear benefit.	Very difficult to implement. Would require relocating residents for a significant period of time and result in considerable disruption to households. Shell's Environmental Health and Safety guidelines/rules would not allow workers to implement other technologies (i.e., excavation) beneath a cribbed house.	Very high capital cost.	Not retained for consideration in remedial alternatives due to ineffectiveness, difficulty of implementation, and cost.
Excavation: *Temporarily Moving Houses to Assist in Excavation*	This technology would require similar processes as lifting and cribbing a house, except the house would be loaded onto a trailer and moved to another location instead of being cribbed.	Ineffective because of lack of clear benefit.	Very difficult to implement. Would require relocating residents for a significant period of time and result in extensive disruption to houses.	Very high capital cost.	Not retained for consideration in remedial alternatives due to ineffectiveness, difficulty of implementation, and cost.
Excavation: *Removal of Residual Concrete Slabs to Assist in Excavation*	Residual concrete slabs, which are former tank farm reservoir side walls and/or floors, are present beneath portions of the Site. Removal would involve excavation. Removal of slabs beneath buildings, hardscape, or streets would require the removal of those Site features and excavation.	The concrete reservoir slab assessment concluded that nothing about the former reservoir slabs would indicate a specific need for their removal. Therefore, removal of all residual concrete slabs is considered unnecessary.	Implementability dependent on scope of removal. Removal of residual concrete slabs when encountered within the boundaries of excavations is relatively easily implemented. Removal beneath paved areas or houses would be very difficult to implement.	Moderate cost to remove slabs when encountered within excavation boundaries.	Removal of residual concrete slabs when encountered within excavation boundaries is retained for consideration in remedial alternatives.
Soil Vapor Extraction (SVE)	Vadose zone vacuum wells are used to remove volatile COCs from soil. Extracted vapors are treated and discharged.	Effective for methane, VOCs, and lighter-range petroleum hydrocarbons. Not effective for non-volatile COCs.	Implementable. SVE wells could be installed in City streets and on residential properties, as appropriate.	Moderate-to-high capital; moderate O&M.	Retained for consideration in remedial alternatives.
Bioventing	Enhances the activity of indigenous bacteria and stimulates the natural in-situ biodegradation of organic COCs in soil by inducing air and oxygen flow into the unsaturated zone.	Potentially more effective than SVE for mid-weight petroleum products on a reasonable timescale.	Implementable. Can be used in conjunction with SVE systems.	Moderate capital, moderate O&M.	Retained for consideration in remedial alternatives. Could be used in conjunction with SVE system/wells.
In-Situ Chemical Oxidation (ISCO)	Introduction of a chemical oxidant into the subsurface for the purpose of transforming groundwater or soil COCs into less harmful chemical species.	Bench-scale pilot testing using representative Site soils indicated that sodium persulfate was not effective and that an excessive quantity of ozone would be required for treatment.	Implementable for saturated zone and groundwater.	Moderate capital, moderate O&M.	Not retained for consideration in remedial alternatives due to demonstrated lack of effectiveness.
Mobile Light Non-Aqueous Phase Liquid (LNAPL) Removal	Direct mobile LNAPL removal from wells where LNAPL has accumulated on top of groundwater to a measurable thickness with sorbent socks or, if LNAPL has accumulated to a thickness of greater than 0.5 foot (6 inches), with a dedicated pump, as is currently done at Site monitoring wells.	Effective for reducing source zone mass/concentration gradients and may reduce time over which concentrations will return to background or MCL levels.	Sorbent socks can be easily implemented. Pumping is currently implemented at Site wells MW-3 and MW-12 and can be implemented in other monitoring wells if LNAPL is discovered on top of groundwater with a depth of 0.5 foot (6 inches) or greater.	Low capital, moderate O&M.	Retained for consideration in remedial alternatives.
Groundwater Monitored Natural Attenuation (MNA)	Naturally occurring processes decrease concentrations of COCs in soil and groundwater. Monitoring is performed to confirm that COC concentrations are decreasing.	Potentially effective for reduction of COC concentrations. Does not mitigate the immediate potential for exposure to impacted materials.	Easily implementable with minimal disruption to current residents.	Minimal cost, associated mainly with monitoring.	Retained. Can be used in conjunction with other remedial technologies.

Table 4-1
Screening of Remedial Technologies

TECHNOLOGY	DESCRIPTION	SCREENING CRITERIA			COMMENTS
		EFFECTIVENESS	IMPLEMENTABILITY	COST	
Contingency In-Siu Groundwater Remediation (If Needed): *Air Sparging with SVE*	Air sparging involves the injection of air into the subsurface saturated zone to enable a transfer of hydrocarbons from a dissolved phase to a vapor phase which is then captured and treated by SVE.	This technology would effectively remediate lighter petroleum hydrocarbons (e.g., gasoline-range hydrocarbons) that volatilize readily but not heavier petroleum hydrocarbons.	Air sparging requires the installation of conveyance pipeline and above-ground treatment facilities and may be more difficult tom implement in some areas due to the location of remediation with respect to houses at the Site.	Moderate capital; high O&M.	Not retained for consideration in remedial alternatives due to lower effectiveness, more difficult implementation, and higher cost.
Contingency In-Siu Groundwater Remediation (If Needed): *Biosparging*	Biosparging involves the pulsed injection of saturated oxygen into the saturated zone to significantly elevate dissolved oxygen concentrations (up to 60 mg/L), which enhances the ability of existing indigenous microorganisms to biodegrade the organic constituents in the saturated zone.	Potentially effective for reducing groundwater COCs and may reduce time over which groundwater will return to background or MCL levels.	Biosparging requires the installation of conveyance pipeline and above-ground treatment facilities and may be more difficult tom implement in some areas due to the location of remediation with respect to houses at the Site.	Moderate capital; high O&M.	Not retained for consideration in remedial alternatives due to lower effectiveness, more difficult implementation, and higher cost.
Contingency In-Siu Groundwater Remediation (If Needed): *Oxidant Injection*	Oxidant injection involves the introduction of an oxidant (e.g., ORC®) that produces a controlled and continuous release of oxygen to the saturated zone. The controlled-release of oxygen to the saturated zone accelerates the development of existing indigenous microorganisms to biodegrade the organic constituents.	Likely more effective for reducing groundwater COCs and may reduce time over which groundwater will return to background or MCL level.	Oxidant injection can be implemented with relative ease assuming oxidant is delivered at the wellhead or through injection; would be subject to a WDR permit.	Low-moderate capital.	Retained for consideration in remedial alternatives.

Table 5-1
Depth of Excavation Considerations

Issue	Excavation to 2 Feet	Excavation to 3 Feet	Excavation to 5 Feet	Excavation to 5 Feet and Targeted to 10 Feet	Excavation to 10 Feet
Utilities Encountered	• None	• None	• Gas service laterals • Telecommunication lines • Landscape irrigation systems • California Water Service Company water mains • Sewer laterals	• Gas service laterals • Telecommunication lines • Landscape irrigation systems • California Water Service Company water mains • Sewer laterals	• Gas service laterals • Telecommunication lines • Landscape irrigation systems • California Water Service Company water mains • Sewer laterals
Residential Hardscape	Removal for Alternative 4A. No removal for Alternative 5A.	Removal for Alternative 4B. No removal for Alternative 5B.	Removal for Alternative 4C. No removal for Alternative 5C.	Removal for Alternative 4D. No removal for Alternative 5D.	Removal for Alternative 4E. No removal for Alternative 5E.
Permitting	• Grading permit required for removal > 50 CY. • SCAQMD Rule 1166, VOC Emissions from Decontamination Soil • Excavation and Encroachment Permits • Asbestos Notifications/ Abatement Permits • OSHA Trenching Permit per 29 CFR 1926.650 • Plumbing and Electrical Permits	• Post-excavation, grading permit required for excavation to ≥3 feet. • SCAQMD Rule 1166, VOC Emissions from Decontamination Soil • Excavation and Encroachment Permits • Asbestos Notifications/ Abatement Permits • OSHA Trenching Permit per 29 CFR 1926.650	• Post-excavation, grading permit required for excavation to ≥3 feet. • SCAQMD Rule 1166, VOC Emissions from Decontamination Soil • Excavation and Encroachment Permits • Asbestos Notifications/ Abatement Permits • OSHA Trenching Permit per 29 CFR 1926.650	• Post-excavation, grading permit required for excavation to ≥3 feet. • SCAQMD Rule 1166, VOC Emissions from Decontamination Soil • Excavation and Encroachment Permits • Asbestos Notification/ Abatement Permits • OSHA Trenching Permit per 29 CFR 1926.650	• Post-excavation, grading permit required for excavation to ≥3 feet. • SCAQMD Rule 1166, VOC Emissions from Decontamination Soil • Excavation and Encroachment Permits • Asbestos Notification/ Abatement Permits • OSHA Trenching Permit per 29 CFR 1926.650
Permitting (Continued)	• Masonry Permit • Landscaping Permit	• Plumbing and Electrical Permits • Masonry Permit • Landscaping Permit	• Plumbing and Electrical Permits • Masonry Permit • Landscaping Permit	• Plumbing and Electrical Permits • Masonry Permit • Landscaping Permit	• Plumbing and Electrical Permits • Masonry Permit • Landscaping Permit

Table 5-1
Depth of Excavation Considerations

Issue	Excavation to 2 Feet	Excavation to 3 Feet	Excavation to 5 Feet	Excavation to 5 Feet and Targeted to 10 Feet	Excavation to 10 Feet
Shoring	• None	• None	• Shoring systems; • Slot trenching; • Sidewalls back-sloped below foundation footings of structures	• Shoring systems; • Slot trenching; • Sidewalls back-sloped below foundation footings of structures	• Shoring systems; • Slot trenching; • Sidewalls back-sloped below foundation footings of structures
Properties Proposed For Remediation	106 Properties Excavated; SVE/Bioventing on 221 Properties	202 Properties Excavated; SVE/Bioventing on 221 Properties	202 Properties Excavated; SVE/Bioventing on 221 Properties	202 Properties Excavated (82 Targeted to 10 feet); SVE/Bioventing on 221 Properties	224 Properties Excavated; SVE/Bioventing on 221 Properties
Volume per property (vertical sidewalls)	Alternative 4A: 7,600 ft^3 (281 CY) Alternative 5A: 2,950 ft^3 (109 CY)	Alternative 4B: 9,890 ft^3 (366 CY) Alternative 5B: 4,010 ft^3 (149 CY)	Alternative 4C: 16,490 ft^3 (611 CY) Alternative 5C: 7,150 ft^3 (265 CY)	Alternative 4D: 19,300 ft^3 (715 CY) Alternative 5D: 8,490 ft^3 (314 CY)	Alternative 4D: 33,000 ft^3 (1,222 CY) Alternative 5D: 14,300 ft^3 (530 CY)

Table 5-2
Preliminary Remedial Alternatives

Alt	Existing ICs	ECs (Sub-Slab Mitigation)	Remove Site Features	Cap Site	Excavate to 2 ft	Excavate to 3 ft	Excavate to 5 ft	Excavate to 5 ft and Targeted Excavation to 10 ft	Excavate to 10 ft	Excavate Beneath Residential Hardscape	Excavate Entire Site	SVE / Bioventing	Groundwater MNA and Contingency Groundwater Remediation	Mobile LNAPL Removal
1*														
2	X		X								X		X	X
3	X		X								X	X	X	X
4A	X	X			X					X		X	X	X
4B	X	X				X				X		X	X	X
4C	X	X					X			X		X	X	X
4D	X	X						X		X		X	X	X
4E	X	X							X	X		X	X	X
5A	X	X			X							X	X	X
5B	X	X				X						X	X	X
5C	X	X					X					X	X	X
5D	X	X						X				X	X	X
5E	X	X							X			X	X	X
6	X		X	X								X	X	X
7	X	X		X								X	X	X

*Alt 1: No Action Alternative

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Table 5-3
Screening of Remedial Alternatives

ALT	DESCRIPTION	SCREENING CRITERIA			STATUS
		EFFECTIVENESS	IMPLEMENTABILITY	COST	
1	No Action No remedial actions, no institutional controls, no engineering controls, and no further monitoring of the site.	Not effective at achieving RAOs.	Easy to implement.	No cost in short or long term.	Retained as a baseline to compare to the remaining alternatives.
2	Removal of all site features and the excavation of impacted soils over the entire Site.	Low effectiveness. Effectively meets RAOs in the long term. Soil, soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA. Relocation would have significant long-term negative impacts on the community.	Very difficult. Relocate all residents. 285 homes and all roads/utilities removed. ~250,000 truckloads of soil, exported and imported to the Site Possibly not be permitted under CEQA. 4 ½ years active remediation	Very High. Highest of all alternatives.	Not retained due to very difficult implementability, very high cost, and long lasting effects on the community.
3	Removal of all site features and the excavation to a depth of 10 feet bgs over the entire Site.	Low effectiveness. Effectively meets RAOs in the long term. Soil goals met in upper 10 feet. Remaining soils meet health goals for infrequent exposure. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA. Relocation would have significant long-term negative impacts on the community.	Very difficult. Relocate all residents. 285 homes and all roads/utilities removed. ~130,000 truckloads of soil Possibly not be permitted under CEQA. 2 ½ years active remediation	Very High. Second highest of all alternatives.	Not retained due to very difficult implementability, very high cost, and long lasting effects on the community.
4A	Excavation of shallow soils to a depth of 2 feet bgs from both landscaped areas and areas covered by hardscape at properties where human health or groundwater goals are exceeded.	High short-term effectiveness, low long-term effectiveness. Effectively meets RAOs in the long term. Soil goals met in upper 2 feet, but not in 2-to-3-foot zone. No existing institutional controls preventing contact with soil from below 2 feet to 3 feet. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	High. 106 properties require excavation. 28 homes would have sub-slab mitigation installed. ~7,000 truckloads of soil Removal of hardscape is inconvenient for residents. Short-term disturbances of community including air quality, noise, and traffic impacts. 1 ½ years active remediation	Moderate.	Not retained due to lack of protectiveness.

Table 5-3
Screening of Remedial Alternatives

ALT	DESCRIPTION	SCREENING CRITERIA			STATUS
		EFFECTIVENESS	IMPLEMENTABILITY	COST	
4B	Excavation of shallow soils to a depth of 3 feet bgs from both landscaped areas and areas covered by hardscape at properties where human health or groundwater goals are exceeded.	Effectively meets RAOs in the long term. Relatively high effectiveness in the short term. Soil goals met in upper 3 feet. Remaining soils meet health goals for infrequent exposure. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	Relatively high. 202 properties require excavation. 28 homes would have sub-slab mitigation installed. 221 properties would have SVE/bioventing infrastructure. ~11,100 truckloads of soil Removal of hardscape is inconvenient for residents. Short-term disturbances of community including air quality, noise, and traffic impacts. 3.0 years active remediation	Moderate to High.	Retained as technically and economically feasible.
4C	Excavation of shallow soils to a depth of 5 feet bgs from both landscaped areas and areas covered by hardscape at properties where human health or groundwater goals are exceeded.	Effectively meets RAOs in the long term. Moderate effectiveness in the short term. Soil goals met in upper 5 feet. Remaining soils meet health goals for infrequent exposure. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	Moderate. 202 properties require excavation. 28 homes would have sub-slab mitigation installed. 221 properties would have SVE/bioventing infrastructure. ~18,100 truckloads of soil Utilities capped, removed and replaced. Removal of hardscape is inconvenient for residents. Short-term disturbances of community including air quality, noise, and traffic impacts. 4.0 years active remediation	High.	Retained as technically and economically feasible.
4D	Excavation of shallow soils to a depth of 5 feet bgs from both landscaped areas and areas covered by hardscape at properties where human health or groundwater goals are exceeded and targeted deeper excavation to 10 feet bgs.	Effectively meets RAOs in the long term. Low effectiveness in the short term. Soil goals met in upper 5 feet; upper 10 feet in areas of additional targeted excavation. Remaining soils meet health goals for infrequent exposure. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	Difficult. 202 properties require excavation. 28 homes would have sub-slab mitigation installed. 221 properties would have SVE/bioventing infrastructure. ~21,100 truckloads of soil Utilities capped, removed and replaced. Removal of hardscape is inconvenient for residents. Short-term disturbances of community including air quality, noise, and traffic impacts. 5.1 years active remediation	High to very high.	Retained as technically and economically feasible.

Table 5-3
Screening of Remedial Alternatives

ALT	DESCRIPTION	SCREENING CRITERIA			STATUS
		EFFECTIVENESS	IMPLEMENTABILITY	COST	
4E	Excavation of shallow soils to a maximum depth of 10 feet bgs from both landscaped areas and areas covered by hardscape at properties where human health or groundwater goals are exceeded.	Effectively meets RAOs in the long term. Very low effectiveness in the short term. Soil goals met in upper 10 feet. Remaining soils meet health goals for infrequent exposure. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	Very Difficult. 224 properties require excavation. 28 homes would have sub-slab mitigation installed. 221 properties would have SVE/bioventing infrastructure. ~39,700 truckloads of soil Utilities capped, removed and replaced. May come in contact with reservoir slabs. Removal of hardscape is inconvenient for residents. Short-term disturbances of community including air quality, noise, and traffic impacts. 7.8 years active remediation	Very high.	Retained as directed by RWQCB.
5A	Excavation of shallow soils to a depth of 2 feet bgs from landscaped areas at properties where human health or groundwater goals are exceeded.	Low effectiveness at meeting RAOs in the long term. Relatively high effectiveness in the short term. Soil goals met in upper 2 feet, but not in 2-to-3-foot zone. No existing institutional controls preventing contact with soil from below 2 feet to 3 feet. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	High. 106 properties require excavation. 28 homes would have sub-slab mitigation installed. 221 properties would have SVE/bioventing infrastructure. ~2,900 truckloads of soil Short-term disturbances of community including air quality, noise, and traffic impacts. 1.2 years active remediation	Moderate.	Not retained due to lack of protectiveness.
5B	Excavation of shallow soils to a depth of 3 feet bgs from landscaped areas at properties where human health or groundwater goals are exceeded.	Moderately effective at meeting RAOs in the long term. Relatively high effectiveness in the short term. Soil goals met in upper 3 feet. Remaining soils meet health goals for infrequent exposure. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	Relatively high. 202 properties require excavation. 28 homes would have sub-slab mitigation installed. 221 properties would have SVE/bioventing infrastructure. ~4,300 truckloads of soil Short-term disturbances of community including air quality, noise, and traffic impacts. 2.5 years active remediation	Moderate.	Retained as technically and economically feasible.

Table 5-3
Screening of Remedial Alternatives

ALT	DESCRIPTION	SCREENING CRITERIA			STATUS
		EFFECTIVENESS	IMPLEMENTABILITY	COST	
5C	Excavation of shallow soils to a depth of 5 feet bgs from landscaped areas at properties where human health or groundwater goals are exceeded.	Moderately effective at meeting RAOs in the long term. Moderate effectiveness in the short term. Soil goals met in upper 5 feet. Remaining soils meet health goals for infrequent exposure. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	Moderate 202 properties require excavation. 28 homes would have sub-slab mitigation installed. 221 properties would have SVE/bioventing infrastructure. ~7,600 truckloads of soil Utilities capped, removed and replaced. Short-term disturbances of community including air quality, noise, and traffic impacts. 3.0 years active remediation	Moderate to high.	Retained as technically and economically feasible.
5D	Excavation of shallow soils to a depth of 5 feet bgs from landscaped areas at properties where human health or groundwater goals are exceeded and targeted deeper excavation to 10 feet bgs.	Moderately effective at meeting RAOs in the long term. Low effectiveness in the short term. Soil goals met in upper 5 feet; upper 10 feet in areas of additional targeted excavation. Remaining soils meet health goals for infrequent exposure. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	Difficult 202 properties require excavation. 28 homes would have sub-slab mitigation installed. 221 properties would have SVE/bioventing infrastructure. ~9,100 truckloads of soil Utilities capped, removed and replaced. Short-term disturbances of community including air quality, noise, and traffic impacts. 4.0 years active remediation	Moderate to high.	Retained as technically and economically feasible.
5E	Excavation of shallow soils to a maximum depth of 10 feet bgs from landscaped areas at properties where human health or groundwater goals are exceeded.	Moderately effectively meets RAOs in the long term. Very low effectiveness in the short term. Soil goals met in upper 10 feet. Remaining soils meet health goals for infrequent exposure. Soil vapor and nuisance goals met. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	Very Difficult. 224 properties require excavation. 28 homes would have sub-slab mitigation installed. 221 properties would have SVE/bioventing infrastructure. ~16,900 truckloads of soil Utilities capped, removed and replaced. May come in contact with reservoir slabs. Short-term disturbances of community including air quality, noise, and traffic impacts. 5.6 years active remediation	High to very high.	Retained as directed by RWQCB.

Table 5-3
Screening of Remedial Alternatives

ALT	DESCRIPTION	SCREENING CRITERIA			STATUS
		EFFECTIVENESS	IMPLEMENTABILITY	COST	
6	Removal of all site features and cap entire site.	Effectively meets RAOs in the long term. Low effectiveness in the short term. Meet human health goal for infrequent exposure to soils Meet nuisance goals by limiting contact with soil and soil vapor Limited removal of COCs from soils. Soil vapor goals for methane and vapor intrusion may not be met in some areas but no receptors. LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	Very Difficult Relocate all residents. 285 homes and all roads/utilities removed. ~12,500 truckloads of import fill and construction debris Possibly not be permitted under CEQA. 4.5 years at minimum active remediation	Very high.	Not retained due to very difficult implementability and very high cost.
7	Cap all exposed soils on-site.	Effectively meets RAOs in the long term. High effectiveness in the short term. Meet human health goal for infrequent exposure to soils Meet nuisance goals by limiting contact with soil and soil vapor Limited removal of COCs from soils. Soil vapor goals for methane and vapor intrusion addressed using sub-slab mitigation LNAPL effectively addressed through LNAPL removal. Groundwater goals achieved in long term through MNA.	Moderate 285 properties require capping 28 homes require sub-slab mitigation. 221 properties would have SVE/bioventing infrastructure. Short-term disturbances of community including air quality, noise, and traffic impacts. All landscaping above cap in long-term Potentially significant increases in stormwater runoff could occur 1.1 years	Moderate.	Retained as technically and economically feasible.

Table 5-4
Retained Remedial Alternatives

Alt	Existing ICs	ECs (Sub-Slab Mitigation)	Cap Site	Excavate to 3 ft	Excavate to 5 ft	Excavate to 5 ft and Targeted Excavation to 10 ft	Excavate to 10 ft	Excavate Beneath Residential Hardscape	SVE / Bioventing	Groundwater MNA and Contingency Groundwater Remediation	Mobile LNAPL Removal
1*											
4B	X	X		X				X	X	X	X
4C	X	X			X			X	X	X	X
4D	X	X				X		X	X	X	X
4E	X	X					X	X	X	X	X
5B	X	X		X					X	X	X
5C	X	X			X				X	X	X
5D	X	X				X			X	X	X
5E	X	X					X		X	X	X
7	X	X	X						X	X	X

*Alt 1: No Action Alternative

Table 6-1
Summary of Estimated Excavation Costs, Mass Removed, Durations and Relocation Time: Alternatives 4B-4E

Alternative	Scope	Cost and Duration Based on Excavation of Four Properties at Time										
		Est Cost ($)	Incremental Cost Above Preceding Alternative	Chemical Mass Removed (lbs)[2]	Incremental Chemical Mass (lbs) Removed Above Preceding Alternative	Incremental Cost ($) Per Incremental Pound of Chemical Mass Removed	% Chemical Mass Removed From Top 10 ft	Incremental % Chemical Mass Removed Above Preceding Alternative	% Chemical Mass Removed From Entire Site	Incremental % Chemical Mass Removed Above Preceding Alternative	Duration (yrs)	Est Relocation Time Per Property (days)
4B	Excavate hard and softscape to 3 ft bgs at 202 properties (74,000 CY total)	$95,000,000 [1]		200,000			4.6%		1.2%		3.0	35
4C	Excavate hard and softscape to 5 ft bgs at 202 properties (123,400 CY total)	$121,000,000	$26,000,000	480,000	280,000	$93	11.1%	6.6%	2.9%	1.7%	4.0	49
4D	Excavate hard and softscape to 5 ft bgs at 202 properties (123,400 CY total), plus targeted deeper excavation from 5-10 ft bgs at 82 properties (21,000 CY)	$132,000,000	$11,000,000	1,490,000	1,010,000	$11	34.5%	23.3%	9.0%	6.1%	5.1	56
4E	Excavate hard and softscape to 10 ft bgs at 224 properties (273,800 CY total)	$204,000,000	$72,000,000	2,020,000	530,000	$136	46.8%	12.3%	12.3%	3.2%	7.8	70

[1] Baseline cost of Alternative 4B is $435 per pound of COC Mass Removed.

[2] Mass removed is cumulative for each alternative.

Table 6-2
Federal ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Safe Drinking Water Act (40 USC Section 300)				
40 CFR Part 141 Subpart B	National Primary Drinking Water Standards	Establishes maximum contaminant levels (MCLs) which are health based standards for public water systems. EPA has promulgated MCLs for inorganic chemicals (41 CFR 141.11), organic chemicals (41 CFR 141.12), turbidity (41 CFR 141.13) and radioactivity (41 CFR 141.15).	Yes	Applicable if affected groundwater is a drinking water source.
		The SDWA also establishes secondary standards for sources of public drinking water. These Maximum Contaminant Level Goals (MCLGs) are non-promulgated and generally non-enforceable standards. They are, however, intended to provide guidance as to levels of contamination that are protective of human health; and pursuant to CERCLA § 121(d)(2)(A) remedial actions selected at CERCLA sites must require a level or standard of control which at least attains MCLGs established under the SDWA and water quality criteria established under sections 304 or 303 of the Clean Water Act, where such goals or criteria are relevant and appropriate under the circumstances of the release or threatened release.		
		In determining the relevance and appropriateness of MCLGs, the most important factors to consider are the designated uses of the water and the purpose for which the potential requirements are intended. Regulations promulgated by EPA require that MCLGs that are set at non-zero levels "shall be attained by remedial actions for groundwater or surface water that are current or potential sources of drinking water, where the MCLGs are relevant and appropriate to the circumstances of the release based on the factors in [40 CFR] § 300.400(g)(2). If an MCLG is determined not to be relevant and appropriate, the corresponding MCL shall be attained where relevant and appropriate to the circumstances of the release." 40 CFR § 300.430(e)(2)(B). Thus, MCLGs are potential ARARs even though not generally enforceable.		

Table 6-2
Federal ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Safe Drinking Water Act (40 USC Section 300) (Cont.)				
40 CFR Part 143	National Secondary Drinking Water Standards	The SDWA established National Secondary Drinking Water Regulations consisting of Secondary Maximum Contaminant Levels (SMCLs). These standards are set to regulate aesthetic qualities of drinking water (e.g., odor, color). SMCLs are non-enforceable guidance and are therefore TBCs for the Site.	Yes	Applicable if affected groundwater is a drinking water source.
40 CFR Part 144	Underground Injection Control (UIC) Program	UIC provides substantial requirements and permit requirements for construction and operation of underground injection wells. The technical and procedural requirements vary according to the class of well installed. These include construction, operating, monitoring, and closure requirements. Since reinjection of extracted groundwater is not within 1/4 mile of an underground drinking water source, the injection wells would be classified as either a Class IV well or a Class V well depending on the nature of the material injected. Class IV wells allow injection of nonhazardous wastewater into an aquifer as part of a CERCLA remedial action (40 CFR 144.13). No construction, operation, monitoring or closure criteria are established for Class IV wells (40 CFR 146, Subpart E). Class V wells inject non-hazardous materials. SDWA also authorized the UIC permit program (40 CFR 144). This program requires owners and operators of certain classes of underground injection wells to obtain permits in order to operate the wells. The permit applicant must show that the underground injection will not endanger drinking water sources. Any wells constructed off Site would be required to be permitted by the appropriate state agency or EPA and to comply with the UIC permit program. All Class I, III, IV, and V wells under the UIC program are administered by EPA. 40 CFR § 147.251. Only Class II wells are administered by the State of California.	Yes	If reinjection takes place in wells that are installed entirely on Site, no UIC permits would be required, but the substantive provisions of the program would be applicable. Alternatively, if some reinjection wells discharge into areas of groundwater units that are not part of the Site, both the substantive and administrative portions of the UIC would be applicable.

Table 6-2
Federal ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Safe Drinking Water Act (40 USC Section 300) (Cont.)				
		The permitting provisions of 40 CFR Part 144 contain only a few specific requirements for Class IV wells (which are otherwise generally prohibited but are granted an exception for CERCLA corrective actions). These provisions would not be fully applicable for off-site wells if the wells are determined to be Class V wells. Other permit conditions that relate to all classes of injection wells under the UIC would be applicable for injection wells located off-site. See e.g., 40 CFR Subpart E.		
40 CFR Part 131	Ambient Water Quality Criteria (WQC)	CERCLA § 121 requires that a remedial action attain Water Quality Criteria (WQC) where such releases are relevant and appropriate under the circumstances. WQC are non-enforceable guidance developed under the CWA and are used by the state, in conjunction with a designated use of a surface water segment, to establish water quality standards under CWA § 303. WQC established under Section 304 of CWA (51 FR 43665), are non-promulgated guidance values based on effects on human health and aquatic life that do not reflect technological or economic considerations. CWA WQCs would pertain to water discharged to, or site runoff directed to, a water body (including a storm drain or flood channel) and surface water containing contaminated sediments from the Site with or without treatment.	Yes	Ambient WQC for some of the organic and inorganic contaminants in the groundwater at the Site have been developed. Substantive requirements would apply if contaminated or treated groundwater is discharged to surface water during a remedial action.
40 CRF Parts 122 and 125	National Pollutant Discharge Elimination System Permit Regulations	Requires permits for the discharge of pollutants from any point source into waters of the United States (U.S.). Both on-site and off-site storm water discharges from CERCLA sites to surface waters are required to meet the substantive CWA NPDES requirements, including discharge limitations, monitoring requirements, and best management practices. Off-site stormwater or process discharges to surface waters must be NPDES-permitted. Stormwater runoff from the site does not need an NPDES permit (40 CFR 122.26). Surface water discharge requirements (except permitting) are applicable regulations for stormwater discharges.	Yes	A permit is not required for on-site CERCLA response actions, but the substantive requirements would apply if treated groundwater is discharged to surface water during a remedial action.
Safe Drinking Water Act (40 USC Section 300) (Cont.)				
40 CFR Parts 403 and 414	National Pretreatment	Standards control the introduction of pollutants which pass through or interfere with treatment processes in publicly owned treatment works (POTWs). This	Yes	If an alternative involves discharge to publicly owned

Table 6-2
Federal ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
	Standards	prevents interference with the operation of a POTW, prevents pass through of pollutants through the treatment works, and improves opportunities to recycle and reclaim municipal and industrial wastewater and sludges.		treatment works, these substantive standards would be applicable.
CWA § 402 (a)(1)	Water Quality Standards	Effluent limitations are required to achieve all appropriate state water quality standards. EPA "Policy for the Development of Water Quality-Based Permit Limitations for Toxic Pollutants" (49 FR 9016, March 9, 1984) states that toxic pollutants contained in direct discharges will be controlled beyond Best Available Technology (BCT/BAT) equivalents in order to meet applicable state water quality standards. Section 303 of the CWA requires states to promulgate water quality standards. Discharges to the storm drain pertain here, such as site rainwater runoff. TBC for reinjection of groundwater in absence of direct discharge.	Yes	To be considered for reinjection of groundwater in absence of other ARARs.
CWA 402(p)	Storm Water Discharge Requirements	The Water Quality Act of 1987 added Section 402(p) to the CWA. See 33 U.S.C. § 1342(p). Section 402(p) establishes a framework for regulating industrial storm water discharges under the NPDES program. Of the five types of stormwater discharges required to have permits under Section 402(p), only one is relevant to the Site -- Section 402(p) prohibits any discharge that EPA or the state determines "contributes to a violation of a water quality standard or is a significant contributor of pollutants to the waters of the United States." CWA § 402(p)(2)(E). California has been authorized to implement the NPDES program for the state and the State Water Resources Control Board (SWRCB) has issued regulations governing storm water permitting under the CWA. See 40 CFR § 122.26(b)(14) (industries covered by the SWRCB's general permit requirements are coextensive with those covered by the federal permit program). A discussion of the substantive requirements of the SWRCB's storm water discharge requirements are discussed below under the state ARARs.	No	Remedial activities that result in a surface water discharge are expected to be conducted entirely on-site; it will not be required to meet the administrative or permitting requirements of this provision.
Clean Air Act (CCA)				
40 CFR Part 50	National Ambient Air Quality Standards	National primary and secondary ambient air quality standards are defined under Section 109 of the CAA and are listed in 40 CFR 50.	Yes	These specific requirements are discussed in the table below relating to State and Local

Table 6-2
Federal ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
	(NAAQS)	CERCLA sites are not considered major sources under the CAA unless emissions equal or exceed 100 tons per year of the pollutants for which the area is designated non-attainment. State implementation plans contain the specific regulations which govern the emission rates for such areas.		ARARs.
40 CFR Part 61	National Emission Standards for Hazardous Air Pollutants (NESHAPs)	NESHAPs are process and industry specific. The NESHAP standards were promulgated to protect public health and the environment but are specific to industrial emissions. NESHAP standards are currently limited to very few chemicals for specific sources of those contaminants (40 CFR 61). The standard for benzene, the only chemical found at the Site for which a NESHAP standard exists varies depending upon the industrial process. The Fugitive Emission Source regulations of 40 CFR Subpart V (§ 61.240 to § 61.247) apply to equipment that is used in volatile hazardous air pollutant (VHAP) service. The VHAPs regulated under this subpart are benzene and vinyl chloride. This subpart only applies if VHAP equipment comes into contact with a VHAP in excess of 10% by weight. The overall concentration of benzene in extracted groundwater from the Site would be present at only a small fraction of the level of contamination intended to be regulated by this subpart. Consequently, these fugitive emission regulations are not appropriate for the major processes	No	Since benzene is not anticipated to be present at levels regulated under NESHAPs, these standards are not applicable. Nor are NESHAPs relevant and appropriate for the remedial activities anticipated since the "fugitive leaks" regulations apply to equipment contacting benzene at concentrations greater than 10% by weight.

Table 6-2
Federal ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Other Applicable Acts				
19 CFR 1910	Occupational Safety and Health Act (OSHA)	The application of OSHA is controlled by the National Contingency Plan (NCP) 40 CFR § 300.150. OSHA requirements under 19 CFR 1910.120 are applicable to worker exposures during response actions at CERCLA sites, except in states that enforce equivalent or more stringent requirements. Response actions under the NCP must comply with the provisions for response action worker safety and health in 29 CFR 1910.120. Federal OSHA requirements include: Construction Standards (29 CFR Part 1926), General Industry Standards (29 CFR Part 1926), General Industry Standards (29 CFR Part 1910), and the general duty requirements of OSHA § 5(a)(1) (29 USC § 654(2)(1). OSHA exposure limits are developed for 8-hour worker exposures; these standards however could be considered in the protection of people in their homes. Exceeding OSHA standards in a home is likely to be more hazardous than on-site worker exposures.	Yes	Is relevant and appropriate in order to maintain worker safety and health while working on the Site.
40 CFR 204, 205, 211	Noise Control Act of 1972 as amended by the Quiet Communities Act of 1978	Construction and Transportation equipment noise levels (e.g., portable air compressors, and medium and heavy trucks), process equipment noise levels and noise levels at the property boundaries of the project are regulated under this act State or local agencies typically enforce these levels.	Yes	Applicable to process equipment noise levels and noise levels at the properties boundaries.

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Hazardous Waste Control Act under the California Code of Regulations Title 22				
H&SC §§ 25100-25395 under 22 CCR 66300	Standards for Management of Hazardous Wastes	The HWCA has many elements that are intended to control hazardous wastes from their point of generation through accumulation, transportation, treatment, storage, and ultimate disposal. It is implemented largely through regulations under the California Code of Regulations (CCR), Title 22, Section 66300 et seq. All surface impoundments, waste piles, and land treatment facilities must be designed, constructed, and maintained to withstand the maximum credible earthquake. The level of public health and environmental protection incorporated in the original design should not be decreased (67108(a) and (b)).	Yes	Since there are no landfills in any groundwater remedial alternative, these regulations will only be TBC.
22 CCR §§ 66261.21 to 66261.24	Criteria for Identifying Hazardous Wastes	If a chemical is either listed or tested and found to possess characteristics that are hazardous, then remedial actions must comply with the hazardous waste requirements under Title 22. Total Threshold Limit Concentrations (TTLCs) and Soluble Threshold Limit Concentrations (STLCs) have been established for selected toxics to be used in establishing whether waste is hazardous.	Yes	If a chemical is either listed or tested and found hazardous, then remedial actions must comply with the hazardous waste requirements under Title 22.
22 CCR §§ 66262.10-66262.70	Standards Applicable to Generators of Hazardous Waste	An owner or operator who initiates a shipment of hazardous waste from a Transport, Storage, or Disposal (TSD) facility must comply with the generator standards established under Title 22, Chapter 12. These standards include keeping of manifests (66262.20), pre-transport requirements (66262.30), record keeping and reporting requirements (66262.00). This regulation is applicable to hazardous waste resulting from treatment of groundwater that accumulates on-site and is shipped off-site for disposal. This regulation is TBC for site activities which do not result in generation or disposal of hazardous waste. This regulation is TBC for site activities which do not result in generation or disposal of hazardous waste.	Yes	This regulation is applicable to hazardous waste resulting from treatment of groundwater that accumulates on-site and is shipped off-site for disposal.

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Hazardous Waste Control Act under the California Code of Regulations Title 22 (Cont.)				
22 CCR §§ 66263.10 to 66263.18	Standards Applicable to Transporters of Hazardous Waste	If hazardous wastes are generated through the treatment process and then must be transported off-site the substantive portions of these regulations would be applicable. The regulations require that transporters of hazardous waste; be registered, have the appropriate kinds of containers, adhere to mandated monitoring procedures, meet record keeping requirements, and take appropriate action in the even of a discharge.	Yes	Only transportation of hazardous waste off-site is required to meet these requirements.
22 CCR §§ 66264.10-66264.708	Standards For Owners and Operators of Hazardous Waste Transfer, Treatment, Storage, and Disposal Facilities	General facility standards (Article 2), Preparedness and Prevention Requirements (Article 3), Contingency Plan and Emergency Procedures (Article 4), and Manifest System (Article 5) are generally applicable for those treatment processes involved in soil remediation. Reinjection could be considered "disposal" if the "contained-in" rule is not applicable.	No	These provisions are not applicable to the Site itself, since it is not a TSDF, but would apply to those processes that treat, store or dispose of hazardous wastes.
22 CCR §§ 66264.110-66264.120	Closure and Post-Closure	Requires closure plans and general closure requirements for disposal and decontamination of equipment at closure.	Yes	Relevant and appropriate for decontamination of equipment at the Site.
22 CCR §§ 66264.170-*66264.199	Use and Management of Containers and Tank Systems	Containers used to transfer or store hazardous wastes must be compatible with wastes stored, managed appropriately, inspected, and designed and operated appropriately. Tank systems must meet design standards and provide for: containment and detection/monitoring of leaks, monitoring and inspection, and proper closure procedures.	Yes	Applicable for those alternatives which contemplate the usage of tanks and/or containers as part of the remedial alternative.

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Hazardous Waste Control Act under the California Code of Regulations Title 22 (Cont.)				
22 CCR §§ 66266.1-66266.120	Recyclable Materials	The substantive provisions of Chapter 16 of Title 22 pertain to recycling materials that are both economically and technologically feasible to be recycled. It is not expected that any waste streams from the remedial alternatives at the Site will be capable of being recycled as described in the regulations. The waste streams are expected to produce materials that are insufficient purity for resale or recycling. Consequently, this Chapter is not applicable. The intent of this Chapter is to utilize recycling to minimize the amount of hazardous waste that must ultimately be disposed. These regulations are also intended generally to apply to ongoing manufacturing operations and processes that are capable of recycling or reusing materials in the manufacturing process. The intent is to either destroy or safely dispose of these waste streams. The substantive provisions of this chapter are TBCs.	No	These regulations while relevant to minimization of disposal or waste products from ongoing plant operations are no appropriate to the Site remedial activities since facilities associated with the remedial action are generally not capable of reusing the waste stream from the process.
22 CCR §§ 66268.1-66268.124	Land Disposal Restrictions	Specifies the restrictions that apply to the land disposal of certain kinds of wastes. The soil or debris variance from the land ban restrictions of Chapter 18 of Title 22 CCR § 66268.30 to § 66268.35 (exception for CERCLA corrective actions) expired in November 1990. The land disposal restrictions generally will apply as follows to groundwater or treatment residuals: ● If the groundwater is itself and F002 RCRA-listed waste -- then the groundwater is banned from land disposal. 22 CCR § 66268.30(a). ● If the groundwater itself is not a RCRA-listed waste -- then the groundwater is banned from land disposal if it contains greater than 100 mg/kg HOCs. 22 CCR § 66268.32.	Yes	Compounds prohibiting land disposal were detected in groundwater at the Site. The provisions of Chapter 18 will be applicable for remedial alternatives that anticipate the treatment and disposal of wastes containing contaminants in concentrations in excess of those allowed under this chapter

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Hazardous Waste Control Act under the California Code of Regulations Title 22 (Cont.)				
		Chapter 18 specifies treatment requirements for HOCs that are present in concentrations greater than or equal to 1,000 mg/kg. 22 CCR § 66268.42. These treatment requirements will apply if the groundwater contains such concentrations of HOCs. Liquid wastes containing such concentration are required to be incinerated. Chapter 18 also specifies the residual concentration of a contaminant that can be contained in a liquid waste in order for that liquid to be land disposed. ● If the groundwater contains (or is itself) the RCRA-listed waste "F002" then the maximum allowable concentration for land disposal of the waste or treatment residual is 0.15 mg/l (22 CCR § 66268.41(a)) (Table CCWE) (wastewater concentration). ● Liquid wastes containing less than 1,000 mg/kg of HOCs (which are not otherwise RCRA-listed) may be land disposed. 22 CCR § 66238.32(e).		
19 CCR Ch. 3, Subch. 3	Hazardous Materials Release Response Plans and Inventory	Requires businesses that handle hazardous materials to establish a plan for emergency response to a release or threatened release of hazardous material. A handler would be required to report certain releases or threatened releases.	Yes	Applicable to disposal of hazardous materials resulting from treatment processes.

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Porter-Cologne Water Quality Control Act				
23 CCR 2200 to 2714	Water Code (WC)	Porter-Cologne delegates standard-setting authority to the RWQCBs. RWQCB will not dictate specific treatment alternatives but will require that the alternative meet minimum actions levels and perform at a level near the Best Available Technology (BAT) for the chosen alternative, RWQCB emission standards are set on a case-by-case basis and apply to treated wastewater and stormwater runoff. Regulations pertain to land disposal unit design and construction standards that minimize dangers to the waters of the State. Wastes are classified as hazardous, designated, non-hazardous, or inert and must be disposed of accordingly. Regulations regarding water quality protection standards are left to the Regional Water Quality Control Boards (2552). Standards are determined by the RWQCBs on a case-by-case basis based on federal Water Quality Standards and state action levels. Actions taken by public agencies to clean up pollution are exempt from the requirements of Title 23, provided that redisposal and containment meet applicable standards.	Yes	If met, these standards are not considered applicable but will remain relevant.
	Los Angeles RWQCB	Regional Boards may prescribe individual or general waste discharge requirements for discharges of site-specific, contaminant-specific, or inert wastes. The RWQCB often references and uses the DTSC action level (AL) standards when the RWQCB determines wastewater discharge standards for site-specific discharges. The RWQCB does not have their own list of ALs. The DTSC ALs is guidance and therefore to be considered (TBC).	Yes	Although the RWQCB applies and enforces the DTSC ALs, the discharge standards are still guidance and are not promulgated so are considered to be TBC.

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Porter-Cologne Water Quality Control Act (Cont.)				
	LACSD Wastewater Ordinance, April 1, 1972 (as amended November 1, 1989	No person shall discharge to the Los Angeles County Sanitation District (LACSD) facilities wastewater containing constituents in excess of effluent limitations defined by the LACSD in its wastewater ordinances. Total Identifiable Chlorinated Hydrocarbons (TICH) allowed: "Essentially None." Additional criteria include maintaining temperature less than 140˚F; pH between 6.0 and 12.0; a flow of material that will not settle or cause an obstruction; and not discharging materials that cause problems in sewer facilities including ammonia, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), priority pollutants, suspended solids, and phenolic compounds. In addition, LACSD may set case by case effluent limitations on certain constituents, including toxic organics, to protect the public health or the LACSD's sewerage facilities. Discharges to Publicly Owned Treatment Works (POTWs) are considered off-site discharges and must meet both the substantive and procedural requirements for any remedial alternatives that include discharges to LACSD sewer system. Regulations for use of LACSD Sewerage Facilities require detailed plans and operating procedures for pretreatment facilities including accidental discharge procedures are submitted to the CSDOC for review.	No	TBC because remedial alternatives do not include discharges to LACSD sewer systems.
Resolution 68-16	State Water Resources Control Board (SWRCB) Antidegradation Policy	The Antidegradation Policy states in part that: Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it had been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated use of such water and will not result in water quality less than that prescribed in the policies.	Yes	The policy states a goal for the nondegradation of groundwaters of the state and because the soil remediation at the Site may impact the groundwater quality of aquifers underling

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Porter-Cologne Water Quality Control Act (Cont.)				
		Resolution No. 68-16 has not been formally promulgated as a rule or regulation pursuant to the established policy making procedures of the California Water Code § 13147, so the resolution is not fully "applicable" as a rule or regulation. However, the Antidegradation Policy has been adopted by the SWRCB and the LARWQCB as a narrative standard of a water quality objective. The Antidegradation Policy states as a narrative standard the goal that "disposal of wastes into the water of the State shall be so regulated as to achieve the highest water quality consistent with maximum benefit to the people of the State ..." Because the Antidegradation Policy states a goal for the nondegradation of groundwaters of the state, and because the soil remediation at the Site may impact the groundwater quality of aquifers underling the Site the Antidegradation Policy is relevant to the Site remedial activities The Antidegradation Policy is also appropriate for the various remedial alternatives for groundwater since the purpose of the policy is to preserve the quality of groundwater, and since the remedial alternatives for groundwater will have an impact on the groundwater aquifers underlying the Site.		the Site, the Antidegradation Policy is relevant to the Site's remedial activities. Waiver of the Antidegradation Policy at the Site may be appropriate if the attainment is impracticable for several reasons, including the difficulty, excessive time frame and cost for removing of DNAPL.

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Porter-Cologne Water Quality Control Act (Cont.)				
		CERCLA § 121(d) provides that, under certain circumstances, ARARs may be waived. The NCP provides for a waiver of ARARs for remedial actions if achievement of the ARAR is technically impracticable. The waiver can be used if either of two criteria are met: (1) engineering feasibility, in which current engineering methods necessary to construct and maintain an alternative that will meet the ARAR cannot reasonably be implemented; and (2) reliability, in which the potential for the alternative to continue to be protective into the future is low, either because the continued reliability of technical and institutional controls is doubtful, or because of inordinate maintenance costs. A remedial alternative that is feasible might be deemed technically impracticable if it could only be accomplished at inordinate cost. See CERCLA Compliance With Other Laws Manual: Interim Final (Part I), EPA/540/G-89/006 (August 1989), and Overview of ARARs, Focus on ARAR Waivers, EPA Publication 9234.2-03/FS (December 1989).		
California Safe Drinking Water Act (Cal-SDWA)				
State Water Resources Control Board Resolution No. 92-49	Policies and Procedures for "Investigation and Cleanup and Abatement of Discharges" California Water Code Section 13000, 13140, 13240, 13260, 13263, 13267, 13300, 13304, 13307	Provides policy and procedures for cleanup and abatement of a discharge, including determining cleanup values. Cleanup shall be to background water quality, or best water quality that is reasonable if background cannot be attained. Requires the application of Title 23 CCR Section 2550.4 Requirements to Cleanups. Considers technological and economic feasibility in determining applicability of cleanup standards.		

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
California Safe Drinking Water Act (Cal-SDWA)				
22 CCR 64435, 64444.5	Maximum Containment Levels (MCLs)	The Cal-SDWA establishes three criteria for evaluating drinking water quality: drinking water standards (MCLs), advisory drinking water action levels (Als), and advisory applied action levels (AALs). The Cal-SDWA establishes limits for substances that may affect health or aesthetic qualities of water and apply "at the tap." The UBA, Gage, and Lynwood aquifers are not currently drinking water sources, therefore these limits are not applicable since they apply to drinking water and not groundwater itself. MCLs are promulgated to provide safe drinking water. Where the RWQCB has promulgated regulations that classify particular aquifers as potential sources of drinking water, these limits are relevant and appropriate to establish standards for remediation.	Yes	These standards will be ARARs at the Site where they set limits more stringent than federal MCLs for aquifers that are potential sources of drinking water for which risk-based exposure limits are not appropriate.
	Advisory Drinking Water Action Levels (ALs)	ALs are health base concentration limits established by the California Department of Health Services (DHS) to aid in limiting public exposure to substances not yet formally regulated. These standards are non-promulgated advisory standards, and are therefore not ARARs.	No	ALs are TBCs because they are intended to be protective of human health and the environment.
H&SC § 25249.5 under 22 CCR § 12000	Toxic Enforcement Act (Proposition 65)	Proposition 65 regulates discharges and exposures of chemicals known to the State of California to be carcinogenic or reproductive toxins. DTSC has adopted regulations regarding no observable effect levels (NOELs) for reproductive toxins and no significant risk levels (NSRLs) for carcinogens.	Yes	This Act is potentially applicable because chemicals detected in groundwater at the Site are listed in Proposition 65, and because individuals may come into contact with these chemicals listed above.

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
California Safe Drinking Water Act (Cal-SDWA) (Cont.)				
		However, Proposition 65 exempts from its warning requirements: "an exposure for which the person responsible can show that the exposure poses no significant risk assuming lifetime exposure at the level in question for substances known to the state to cause cancer, and that the exposure will have no observable effect assuming the exposure at one thousand (1,000) times the level in question for substances known to the state to cause reproductive toxicity..." H&S Code § 25249.10(c). An analysis would need to be performed to determine whether the risk levels expected to emanate from the groundwater treatment processes would release any of the above listed chemicals in concentration that would trigger Proposition 65, or whether the level of exposure would pose no significant risk for carcinogens or if the exposure is 1,000 times the NOEL for reproductive toxins.		
Mulford-Carrell Air Resources Act				
H&SC §§ 3900-44563 under 17 CCR 70200	Implemented by the local Air Quality Management Districts and overseen by the Air Resources Board	Ambient Air Quality Standards listed under Title 17, Sections 70200/70200.5. Ozone (1-hour) 0.09 ppm CO (8-hour) 9.0 ppm (1-hour) 20 ppm NO_2 (1-hour) 0.25ppm SO_2 (24-hour) 0.04ppm (1-hour) 0.25ppm PM_{10} (particulate matter <10 microns) (24 hour annual mean) 30 µg/m^3 Sulfates (24-hour) 50 µg/m^3 Lead (30-day) 25 µg/m^3 H_2S (1-hour) 1.5 µg/m^3 Vinyl Chloride (24-hour) 0.010 ppm	Yes	Although it sets no standards, this code requirement is applicable because it gives authority to local agencies. These standards had intended to be protective of human health and consist of specific compounds they will be TBCs in the absence of other ARARs.

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Mulford-Carrell Air Resources Act (Cont.)				
		Title 17, Section 93000 also identifies benzene and hexavalent chromium as toxic air contaminants at specific industrial locations not applicable to remedial alternatives considered here.		
	South Coast Air Quality Management District (SCAQMD) Rules and Regulations	*Regulation IV -- Prohibitions.* This Act assigns responsibility for the identification of air pollutants to the CDHS and ARB. The ARB and local air pollution control districts must then develop control measures reducing emissions of the identified pollutants. Rule 401 - Visible Emissions. Limits visible emissions from any point source to Ringelmann No. 1, or 20 percent opacity for 3 minutes in any hour. Rule 402 - Nuisance. Prohibits the discharge of any material (including odorous compounds) that causes injury, or annoyance to the public, property, or businesses or endangers human health, comfort, repose, or safety. Rule 403 - Fugitive Dust. Limits on-site activities so that the concentrations of fugitive dust at the property line shall not be visible at the downwind particulate concentration shall not be more than 100 micrograms per cubic meter, averaged over 5 hours, above the upwind particulate concentration. These requirements do not apply if the wind speed, averaged over 15 minutes, is above 15 miles per hour. The rule also requires every reasonable precaution to minimize fugitive dust and the prevention and cleanup of any material accidentally deposited on paved streets.		Depending on the remedial alternative selected, these rules may be relevant and appropriate. With the exception of Rule 430 which is TBC.

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Mulford-Carrell Air Resources Act (Cont.)				
		Rule 430 - Breakdown Provisions. Rule 430 requires reporting of any breakdown which results in a violation of any rule in Regulations IV or XI within one hour after any such breakdown. The report must identify the time, specific location, equipment involved and the extent known, the cause of the breakdown. The estimated time of repairs must be reported as soon as possible thereafter. Within one week of the breakdown which causes a violation of any rule in Regulations IV or XI has been corrected, the operator shall submit a written report to the SCAQMD Director. Because this is an administrative rule, and because the operation of equipment is expected to be entirely on-site, this rule is a TBC. Rule 431.1, 431.2, 431.3 - Sulfur Content of Combustible Fuels. Establishes allowable sulfur contents for combustion fuels. Rule 473 - Disposal of Solid and Liquid Wastes. Incinerators designed to dispose of combustible refuse at burning rates greater than 50 kilograms per hour shall not release particulate matter in excess of 0.23 grams per cubic meter of gas calculated to 12 percent of carbon dioxide (472(b) and (c)). Rule 474 - Fuel-Burning Equipment Oxides of Nitrogen. Limits the concentration of oxides of nitrogen (as NO_2) to a range of 125 to 300 ppm for gaseous fuels and 225 to 400 ppm for solid and liquid fuels depending on equipment size. Rule 476 - Steam Generating Equipment. Prohibits discharge into the atmosphere of certain combustion contaminants from equipment having a heat input rate of more than 50 million BTU. May be applicable depending upon final size of steam generating equipment used for carbon reactivation.		

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Mulford-Carrell Air Resources Act (Cont.)				
		Regulation X -- National Emission Standards for Hazardous Air Pollutants. Implements the provisions of Part 61, Chapter I, Title 40, of the CFR under the supervision of SCAQMD executive Officer, if contaminants identified at the Site are listed. *Regulation XI -- Source Specific Standards* Rules 1146 and 1146.1 - Emission of Oxides of Nitrogen from Industrial, Institutional and Commercial Boilers, Steam Generators, and Process Heaters and Emissions of Oxides of Nitrogen for Small Industrial, Institutional and Commercial Boilers, Steam Generators, and Process Heaters. Prohibits boilers, steam generators, and process heaters rated greater than 5 million BTU/hour (or between 2 million and 5 million for small operators) from discharging in excess of certain limits of nitrogen dioxide (NO_2). Requires emission compliance plan, compliance schedule and compliance determination.		
		Rule 1166 – Volatile Organic Compound Emissions from the Decontamination of Soils This rule sets requirements to control the emission of Volatile Organic Compounds (VOC) from excavating, grading, handling and treating VOC-contaminated soil as a result of leakage from storage or transfer operations, spillage, or other deposition.		
		Rule 1176 - Fugitive Emissions of Volatile Organic Compounds (VOCs). Limits leaks of VOCs from valves, fittings, pumps, compressors and other equipment at refineries, chemical plants and similar processing facilities. While not applicable to the Site, this rule may be relevant and appropriate depending on the remedial alternative selected and the contents of the treatment process pipelines.		

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Mulford-Carrell Air Resources Act (Cont.)				
		Regulation XIII -- New Source Review. This regulation sets forth preconstruction review requirements for new or modified stationary sources, to ensure that the operation of such stationary sources does not interfere with progress in attainment of the national and state ambient air quality standards, without unnecessarily restricting the future economic growth within the district. NAAQS guidelines and emissions limits are on a case-by-case basis. The regulations include requirements for offsets and usage of BACT for certain types of discharges. *Regulation XIV -- Toxics and Other Non-Criteria Pollutants* Rule 1401 - New Source Review of Carcinogenic Air Contaminants. The rule specifies limits for cancer risk and excess cancer cases from new stationary sources and modifications to existing stationary sources that emit carcinogenic air contaminants. The rule establishes allowable emission impacts for all such stationary sources requiring new permits pursuant to SCAQMD Rules 201 or 203. Best Available Control Technology for Toxics (T-BACT) will be required for any system where a lifetime (70 year) maximum individual cancer risk of one is one mission or greater is estimated to occur. Limits are calculated using unit risk factors for specific contaminants. Groundwater contaminants identified at the Site that have identified unit risk factors include BHC, benzene, carbon tetrachloride, chloroform, methylene chloride, trichloroethylene, and 2,4,6-trichlorophenol.		
California Coastal Act of 1976				
14 CCR §§ 13001-13600	Public Resources Code (PRC)	Regulates activities within, or that could discharge to the coastal zone.		TBC since the remedial activities will not take place within the "coastal zone" as defined by PRC § 30103

Table 6-3
State and Local ARARs

Citation	Standard or Requirement	Description	Potentially Applicable or Relevant and Appropriate	Comment
Other Applicable Acts				
Labor Code, Sections 6300 et seq.	California Occupational Health and Safety Act	Establishes the requirements for worker safety and responsibility of employers. Cal-OSHA also establishes exposure limits that are more stringent if not equal to OSHA exposure limits.	Yes	Is relevant and appropriate in order to maintain worker safety and health while working on the Site.
16 USC, Section 469; 36 CFR Part 65	National Archaeological and Historical Preservation Act	Alteration of terrain that threatens significant scientific or historical data may require actions to remove or preserve artifacts.		
Endangered Species Act 1973 50 CFR Part 200; 50 CFR Part 402	Endangered Species Act	Requires action to conserve endangered species.		
Native Plant Protection Act	Native Plant Protection Act	Requires consultation with CDFG if species are affected by the project.		

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Table 6-4
Preliminary Cost Estimate For Alternative 4B

ALTERNATIVE 4B
* Excavate exposed soils and soils under residential hardscape[A] to 3 feet where HH350 goals are exceeded.
* No excavation beneath streets.
* Install subslab mitigation at homes where subslab VOC and methane concentrations exceed screening value.
* MNA remedy for GW. Could add limited hot spot remediation to reduce time to achieve cleanup goals.
* Remove LNAPL as feasible.* SVE/Bioventing

Item	Description	Quantity	Unit	Rate	Amount	Comments
1.0	**Property Purchase Cost (285 properties)**	0	LS	NA	**$ -**	
2.0	**Demolition Costs**				**$ 1,586,508**	Includes 5% handling on outside services
2.1	Asbestos Surveys	0	LS	$ 3,200	$ -	URS Est.
2.2	Asbestos Abatement	0	LS	$ 18,000	$ -	URS Est.
2.3	D & D of Homes	0	LS	$ 35,000	$ -	AIS Est.
2.4	D & D of Hardscape	377,740	SF	$ 4	$ 1,510,960	AIS Est.
3.0	**Excavate, Backfill, & Assoc. Costs**				**$ 38,866,728**	Includes 5% handling on outside services
3.1	Excavate and Load Impacted Soil	74,000	CY	$ 50	$ 3,700,000	202 homes; 1870 sf hardscape, 1430 sf landscape on average, 3' deep
3.2	Remove and Dispose Concrete Bases	0	TONS	$ 80	$ -	AIS Est. (No city sidewalk)
3.3	Shoring (H pile/lagging or sheet pile)	0	SF	$ 40	$ -	
3.4	Vapor Mitigation	202	EA	$ 1,500	$ 303,000	AIS Est.
3.5	T&D Non Haz Soil (Recycle) 100%	125,800	TON	$ 60	$ 7,548,000	Soil Safe, Adelanto AIS Est.
3.6	T&D RCRA Haz Soil (Out of State) 0%	0	TON	$ 215	$ -	Beaty, NV AIS Est.
3.7	Groundwater Remediation	0	LS	$ -	$ -	Assume NMA, no active treatment
3.8	Import Clean Soil	74,000	CY	$ 20	$ 1,480,000	URS Est.
3.9	Backfill and Compact	74,000	CY	$ 9	$ 666,000	AIS Est.
3.10	Fine Grade	15.3	ACRES	$ 30,000	$ 458,678	AIS Est.
3.11	SWPP BMPs	1	LS	$ 150,000	$ 150,000	URS Est.
3.12	Subslab Vapor Mitigation	84	EA	$ 20,000	$ 1,680,000	URS Est.
3.13	Utilities Restoration	202	EA	$ 1,500	$ 303,000	URS Est.
3.14	Landscape/Hardscape	202	EA	$ 45,000	$ 9,090,000	URS Est. Includes $15K block walls
3.15	SVE/Bioventing	1	LS	$ 11,104,115	$ 11,104,115	URS Est.
3.16	Soil Waste Profiling	1	LS	$ 100,000	$ 100,000	URS Est. ~ 1 sample per 500 cy at $630
3.17	Post-excavation Sampling	202	EA	$ 5,000	$ 1,010,000	URS Est. Level of effort of 20 samples per house, TPHg, TPHd, TPHmo & VOCs only at $250/sample
4.0	**Other Direct Costs**				**$ 27,125,723**	Includes 5% handling on outside services
4.1	Contingency for Treatment of Rainwater	1	LS	$ 1,000,000	$ 1,000,000	AIS Est.
4.2	PM, Planning, Permitting, Coordination, Reporting	1	LS	$ 5,097,108	$ 5,097,108	12.6% of Construction $ 25,233 per home
4.3	Grading Permits	202	EA	$ 5,000	$ 1,010,000	
4.4	Geotechnical Investigation/Reports	1	LS	$ -	$ -	
4.5	Field Mgmt, Monitoring, Oversight	1	LS	$ 6,067,985	$ 6,067,985	15.0% of Construction $ 40,053 per week
4.6	Relocation	202	EA	$ 24,500	$ 4,949,000	$ 700 per day 35 days
4.7	Security	152	WEEKS	$ 54,400	$ 8,241,600	5 guards - 16 hours per day/24 hours weekend
5.0	**Post Excavation Construction and Long Term O&M**				**$ 27,808,565**	Includes 5% handling on outside services
5.1	Groundwater Monitoring	30	YEAR	$ 80,000	$ 2,400,000	URS Est. Assume semi-annual monitoring plus MNA parameters
5.2	LNAPL Recovery	112	Events	$ 4,571	$ 511,952	URS Est. $4.6K / event: monthly for 4 years, quarterly for next 6 years and semi-annualy for next 20 years
5.3	SVE/Bioventing O&M	30	YEAR	$ 683,075	$ 20,492,247	URS Est.
5.4	SVE/Bioventing Performance Sampling	1	LS	$ 1,117,920	$ 1,117,920	
5.5	SSP Probe Install at SSD Properties	28	EA	$ 2,800	$ 78,400	
5.6	Periodic Sub-Slab SVP Sampling Prior to SVE/BV Opns	303	Events	$ 2,400	$ 727,200	Assumes 1.5 bi-annual events at 202 properties for 5.5 years (303 events total)
5.7	Periodic Sub-Slab SVP Sampling After Start of SVE/BV Opns	360	events	$ 2,400	$ 864,000	Assumes 120 homes sampled every 5 years for 15 years (remaining 82 homes sampled for SSD systems)
5.7	Sub-slab Soil Vapor Probe Periodic Sampling for SSD	364	Events	$ 2,400	$ 873,600	Assumes will sample 2 SVPs at 28 homes with SSD systems annually for 5 yrs, bi-ann for 10 yrs, and every 5 yrs for 15 yrs
5.8	Asphalt Capping of Streets (1" grind and overlay)	33,000	SY	$ 15	$ 495,000	URS Est.
	Subtotal Estimate Alternative 4B without Contingency				**$ 95,000,000**	
	Total Estimate Alternative 4B with Contingency Range -20% to +30%			**$ 76,000,000**	**$ 124,000,000**	
				Low	**High**	

Estimated Duration	152 Weeks	3.0 Years
Estimated Truck Loads/Day	11 Loads/Day Export	11 Loads/Day Import
Estimated Total Loads	5,785 Loads Export	5,286 Loads Import

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Table 6-5
Preliminary Cost Estimate For Alternative 4C

ALTERNATIVE 4C
Same as Alt 4B except excavate to 5 feet

Item	Description	Quantity	Unit	Rate	Amount	Comments
1.0	**Property Purchase Cost (285 properties)**	0	LS	NA	**$ -**	
2.0	**Demolition Costs**				**$ 1,586,508**	Includes 5% handling on outside services
2.1	Asbestos Surveys	0	LS	$ 3,200	$ -	URS Est.
2.2	Asbestos Abatement	0	LS	$ 18,000	$ -	URS Est.
2.3	D & D of Homes	0	LS	$ 35,000	$ -	AIS Est.
2.4	D & D of Hardscape	377,740	SF	$ 4	$ 1,510,960	AIS Est.
3.0	**Excavate, Backfill, & Assoc. Costs**				**$ 55,868,057**	Includes 5% handling on outside services
3.1	Excavate and Load Impacted Soil	123,400	CY	$ 60	$ 7,404,000	202 homes; 1870 sf hardscape, 1430 sf landscape on average, 5' deep
3.2	Remove and Dispose Concrete Bases	0	TONS	$ 80	$ -	AIS Est.
3.3	Shoring (H pile/lagging or sheet pile)	191,900	SF	$ 30	$ 5,757,000	AIS Est. around each house
3.4	Vapor Mitigation	202	EA	$ 1,500	$ 303,000	AIS Est.
3.5	T&D Non Haz Soil (Recycle) 100%	209,780	TON	$ 60	$ 12,586,800	Soil Safe, Adelanto AIS Est.
3.6	T&D RCRA Haz Soil (Out of State) 0%	0	TON	$ 215	$ -	Beaty, NV AIS Est.
3.7	Groundwater Remediation	0	LS	$ -	$ -	Assume NMA, no active treatment
3.8	Import Clean Soil	123,400	CY	$ 20	$ 2,468,000	URS Est.
3.9	Backfill and Compact	123,400	CY	$ 9	$ 1,110,600	AIS Est.
3.10	Fine Grade	15.3	ACRES	$ 30,000	$ 458,926	AIS Est.
3.11	SWPP BMPs	1	LS	$ 200,000	$ 200,000	URS Est.
3.12	Subslab Vapor Mitigation	84	EA	$ 20,000	$ 1,680,000	URS Est.
3.13	Utilities Restoration	202	EA	$ 2,000	$ 404,000	URS Est.
3.14	Landscape/Hardscape	202	EA	$ 45,000	$ 9,090,000	URS Est. Includes $15K block walls
3.15	SVE/Bioventing	1	LS	$ 11,104,115	$ 11,104,115	URS Est.
3.16	Soil Waste Profiling	1	LS	$ 160,000	$ 160,000	URS Est. ~ 1 sample per 500 cy at $630
3.17	Post-excavation Sampling	202	EA	$ 5,000	$ 1,010,000	URS Est. Level of effort of 20 samples per house, TPHg, TPHd, TPHmo & VOCs only at $250/sample
4.0	**Other Direct Costs**				**$ 35,923,711**	Includes 5% handling on outside services
4.1	Contingency for Treatment of Rainwater	1	LS	$ 1,000,000	$ 1,000,000	AIS Est.
4.2	PM, Planning, Permitting, Coordination, Reporting	1	LS	$ 6,320,002	$ 6,320,002	11% of Construction $ 31,287 per home
4.3	Grading Permits	202	EA	$ 5,000	$ 1,010,000	
4.4	Geotechnical Investigation/Reports	1	LS	$ 606,000	$ 606,000	URS Est.
4.5	Field Mgmt, Monitoring, Oversight	1	LS	$ 8,043,639	$ 8,043,639	14% of Construction $ 39,820 per week
4.6	Relocation	202	EA	$ 34,300	$ 6,928,600	$ 700 per day 49 days
4.7	Security	202	WEEKS	$ 54,400	$ 10,988,800	5 guards - 16 hours per day/24 hours weekend
5.0	**Post Excavation Construction and Long Term O&M**				**$ 28,047,045**	Includes 5% handling on outside services
5.1	Groundwater Monitoring	30	YEAR	$ 80,000	$ 2,400,000	URS Est. Assume semi-annual monitoring plus MNA parameters
5.2	LNAPL Recovery	112	Events	$ 4,571	$ 511,952	URS Est. $4.6K / event: monthly for 4 years, quarterly for next 6 years and semi-annualy for next 20 years
5.3	SVE/Bioventing O&M	30	YEAR	$ 683,075	$ 20,492,247	URS Est.
5.4	SVE/Bioventing Performance Sampling	1	LS	$ 1,117,920	$ 1,117,920	
5.5	SSP Probe Install at SSD Properties	28	EA	$ 2,800	$ 78,400	
5.6	Periodic Sub-Slab SVP Sampling Prior to SVE/BV Opns	404	Events	$ 2,400	$ 969,600	Assumes 2 bi-annual events at 202 properties for 5.5 years (404 events total)
5.7	Periodic Sub-Slab SVP Sampling After Start of SVE/BV Opns	360	events	$ 2,400	$ 864,000	Assumes 120 homes sampled every 5 years for 15 years (remaining 82 homes sampled for SSD systems)
5.7	Sub-slab Soil Vapor Probe Periodic Sampling for SSD	364	Events	$ 2,400	$ 873,600	Assumes will sample 2 SVPs at 28 homes with SSD systems annually for 5 yrs, bi-ann for 10 yrs, and every 5 yrs for 15 yrs
5.8	Asphalt Capping of Streets (1" grind and overlay)	33,000	SY	$ 15	$ 495,000	URS Est.

Subtotal Estimate Alternative 4C without Contingency		**$ 121,000,000**
Total Estimate Alternative 4C with Contingency Range -20% to +30%	**$ 97,000,000**	**$ 157,000,000**
	Low	**High**

Estimated Duration	202 Weeks	4.0 Years
Estimated Truck Loads/Day	12 Loads/Day Export	12 Loads/Day Import
Estimated Total Loads	9,314 Loads Export	8,814 Loads Import

Table 6-6
Preliminary Cost Estimate For Alternative 4D

ALTERNATIVE 4D
Same as Alt 4B except excavate to 5 feet with 5-10' in Localized Areas Under Hardscape and Landscape

Item	Description		Quantity	Unit	Rate	Amount	Comments
1.0	**Property Purchase Cost ( )**		0	LS	$ 345,000	**$ -**	Average of recent sales compiled by Sheri Repp, City of Carson
							Assume 4 houses for SVE system footprint/yard
2.0	**Demolition Costs**					**$ 1,586,508**	Includes 5% handling on outside services
2.1	Asbestos Surveys		0	LS	$ 3,200	$ -	URS Est.
2.2	Asbestos Abatement		0	LS	$ 18,000	$ -	URS Est.
2.3	D & D of Homes		0	LS	$ 35,000	$ -	AIS Est.
2.4	D & D of Hardscape		377,740	SF	$ 4	$ 1,510,960	AIS Est. excludes city sidewalk
3.0	**Excavate, Backfill, & Assoc. Costs**					**$ 60,227,128**	Includes 5% handling on outside services
3.1	Excavate and Load Impacted Soil	0-5 ft	123,400	CY	$ 60	$ 7,404,000	202 homes; 1870 sf hardscape, 1430 sf landscape on average, 5' deep
3.1.1	Excavate and Load Impacted Soil - Backhoe 67%	5-10 ft	14,070	CY	$ 80	$ 1,125,600	82 front and back yards
3.1.2	Excavate and Load Impacted Soil - Auger 33%	5-10 ft	6,930	CY	$ 225	$ 1,559,250	
3.2	Remove and Dispose Concrete Bases		3,769	TONS	$ 80	$ 301,500	AIS Est. (excludes city sidewalk)
3.3	Shoring (H pile/lagging or sheet pile)		0	SF	$ 40	$ -	
3.4	Vapor Mitigation		202	EA	$ 2,500	$ 505,000	AIS Est.
3.5	T&D Non Haz Soil (Recycle) 100% 0-5 ft & 67% 5-10 ft		233,699	TON	$ 60	$ 14,021,940	Soil Safe, Adelanto AIS Est. 1.7 tons/cy
3.6	T&D RCRA Haz Soil (Out of State) 33% of 5-10 ft		11,781	TON	$ 215	$ 2,532,915	Beaty, NV AIS Est.
3.7	Groundwater Remediation		1	LS	$ -	$ -	Assume MNA and no active treatment
3.8	Import Clean Soil		123,400	CY	$ 20	$ 2,468,000	URS Est.
3.8.1	2 Sack Slurry Backfill		21,000	CY	$ 100	$ 2,100,000	URS Est.
3.9	Backfill and Compact		123,400	CY	$ 9	$ 1,110,600	AIS Est.
3.10	Fine Grade		15.3	ACRES	$ 30,000	$ 458,926	AIS Est.
3.11	SWPPP BMPs		1	LS	$ 500,000	$ 500,000	URS Est.
3.12	Subslab Vapor Mitigation		84	EA	$ 20,000	$ 1,680,000	Geosyntec Est. based on AF of 0.002 and a safety factor of 2
3.13	Utilities Restoration		202	EA	$ 5,000	$ 1,010,000	URS Est.
3.14	Landscape/Hardscape		202	EA	$ 45,000	$ 9,090,000	URS Est. Includes $15K block walls
3.15	SVE/Bioventing		1	LS	$ 10,814,410	$ 10,814,410	URS Est.
3.16	Soil Waste Profiling		1	LS	$ 182,000	$ 182,000	URS Est. ~ 1 sample per 500 cy at $630
3.17	Post-excavation Sampling		202	EA	$ 5,000	$ 1,010,000	URS Est. Level of effort of 20 samples per house, TPHg, TPHd, TPHmo & VOCs only at $250/sample
4.0	**Other Direct Costs**					**$ 42,259,702**	Includes 5% handling on outside services
4.1	Contingency for Treatment of Rainwater		1	LS	$ 1,000,000	$ 1,000,000	AIS Est.
4.2	PM, Planning, Design, Coordination, Reporting		1	LS	$ 6,799,500	$ 6,799,500	11% of Construction $ 33,661 per home
4.3	Grading Permits		202	EA	$ 5,000	$ 1,010,000	URS Est.
4.4	Geotechnical Investigation/Reports		1	LS	$ 688,000	$ 688,000	URS Est.
4.5	Field Mgmt, Monitoring, Oversight		1	LS	$ 9,890,182	$ 9,890,182	16% of Construction $ 39,169 per week
4.6	Relocation		202	EA	$ 39,200	$ 7,918,400	$ 700 per day 56 days
4.7	Security		253	WEEKS	$ 54,400	$ 13,736,000	5 guards - 16 hours per day/24 hours weekend
5.0	**Post Excavation Construction and Long Term O&M**					**$ 28,289,466**	Includes 5% handling on outside services
5.1	Groundwater Monitoring		30	YEARS	$ 80,000	$ 2,400,000	URS Est. Assume semi-annual monitoring plus MNA parameters
5.2	LNAPL Recovery		112	events	$ 4,571	$ 511,973	URS Est. $4.6K / event: monthly for 4 years, quarterly for next 6 years and semi-annualy for next 20 years
5.3	SVE/Bioventing O&M		30	YEAR	$ 683,075	$ 20,492,247	URS Est.
5.4	SVE/Bioventing Performance Sampling		1	LS	$ 1,117,920	$ 1,117,920	
5.5	SSP Probe Install at SSD Properties		28	EA	$ 2,800	$ 78,400	
5.6	Periodic Sub-Slab SVP Sampling Prior to SVE/BV Opns		505	Events	$ 2,400	$ 1,212,000	Assumes 2.5 bi-annual events at 202 properties for 5.5 years (505 events total)
5.7	Periodic Sub-Slab SVP Sampling After Start of SVE/BV Opns		360	events	$ 2,400	$ 864,000	Assumes 120 homes sampled every 5 years for 15 years (remaining 82 homes sampled for SSD systems)
5.7	Sub-slab Soil Vapor Probe Periodic Sampling for SSD		364	Events	$ 2,400	$ 873,600	Assumes will sample 2 SVPs at 28 homes with SSD systems annually for 5 yrs, bi-ann for 10 yrs, and every 5 yrs for 15 yrs
5.8	Asphalt Capping of Streets (1" grind and overlay)		33,000	SY	$ 15	$ 495,000	URS Est.

	Low	High
Subtotal Estimate Alternative 4D without Contingency		**$ 132,000,000**
Total Estimate Alternative 4D with Contingency Range -20% to +30%	**$ 106,000,000**	**$ 172,000,000**
Total Estimate with Contingency Range -10% to +15%	**$ 119,000,000**	**$ 152,000,000**

Estimated Duration	Excavation duration + 1.5 week	253 Weeks	5.1 Years
Estimated Truck Loads/Day	4 houses at a time	12.2 Loads/Day Export	12.24 Loads/Day Import
Estimated Total Loads	3.5 weeks per house to excavate	10,814 Loads Export	10,314 Loads Import

Table 6-7
Preliminary Cost Estimate Alternative 4E

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ALTERNATIVE 4E
Same as Alt 4B except excavate to 10 feet

Item	Description	Quantity	Unit	Rate	Amount	Comments
1.0	**Property Purchase Cost (285 properties)**	0	LS	NA	**$ -**	
2.0	**Demolition Costs**				**$ 1,759,296**	Includes 5% handling on outside services
2.1	Asbestos Surveys	0	LS	$ 3,200	$ -	URS Est.
2.2	Asbestos Abatement	0	LS	$ 18,000	$ -	URS Est.
2.3	D & D of Homes	0	LS	$ 35,000	$ -	AIS Est.
2.4	D & D of Hardscape	418,880	SF	$ 4	$ 1,675,520	AIS Est.
3.0	**Excavate, Backfill, & Assoc. Costs**				**$ 111,849,645**	Includes 5% handling on outside services
3.1	Excavate and Load Impacted Soil	273,800	CY	$ 80	$ 21,904,000	224 homes; 1870 sf hardscape, 1430 sf landscape on average, 10' deep
3.2	Remove and Dispose Concrete Bases	166	TONS	$ 80	$ 13,266	AIS Est.
3.3	Shoring (H pile/lagging or sheet pile)	425,600	SF	$ 50	$ 21,280,000	AIS Est. around each house
3.4	Vapor Mitigation	224	EA	$ 1,500	$ 336,000	AIS Est.
3.5	T&D Non Haz Soil (Recycle) 98%	456,151	TON	$ 60	$ 27,369,048	Soil Safe, Adelanto AIS Est.
3.6	T&D RCRA Haz Soil (Out of State) 2%	9,309	TON	$ 215	$ 2,001,478	Beaty, NV AIS Est.
3.7	Groundwater Remediation	0	LS	$ -	$ -	Assume NMA, no active treatment
3.8	Import Clean Soil	273,800	CY	$ 20	$ 5,476,000	URS Est.
3.9	Backfill and Compact	273,800	CY	$ 9	$ 2,464,200	AIS Est.
3.10	Fine Grade	17.0	ACRES	$ 30,000	$ 509,132	AIS Est.
3.11	SWPP BMPs	1	LS	$ 250,000	$ 250,000	URS Est.
3.12	Subslab Vapor Mitigation	84	EA	$ 20,000	$ 1,680,000	URS Est.
3.13	Utilities Restoration	224	EA	$ 5,000	$ 1,120,000	URS Est.
3.14	Landscape/Hardscape	224	EA	$ 45,000	$ 10,080,000	URS Est. Includes $15K block walls
3.15	SVE/Bioventing	1	LS	$ 11,104,115	$ 11,104,115	URS Est.
3.16	Soil Waste Profiling	1	LS	$ 345,000	$ 345,000	URS Est. ~ 1 sample per 500 cy at $630
3.17	Post-excavation Sampling	224	EA	$ 5,000	$ 1,120,000	URS Est. Level of effort of 20 samples per house, TPHg, TPHd, TPHmo & VOCs only at $250/sample
4.0	**Other Direct Costs**				**$ 60,940,518**	Includes 5% handling on outside services
4.1	Contingency for Treatment of Rainwater	1	LS	$ 1,000,000	$ 1,000,000	AIS Est.
4.2	PM, Planning, Permitting, Coordination, Reporting	1	LS	$ 7,952,626	$ 7,952,626	7% of Construction $ 35,503 per home
4.3	Grading Permits	224	EA	$ 5,000	$ 1,120,000	
4.4	Geotechnical Investigation/Reports	1	LS	$ 896,000	$ 896,000	URS Est.
4.5	Field Mgmt, Monitoring, Oversight	1	LS	$ 15,905,252	$ 15,905,252	14% of Construction $ 40,575 per week
4.6	Relocation	224	EA	$ 49,000	$ 10,976,000	$ 700 per day 70 days
4.7	Security	392	WEEKS	$ 54,400	$ 21,324,800	5 guards - 16 hours per day/24 hours weekend
5.0	**Post Excavation Construction and Long Term O&M**				**$ 29,016,645**	Includes 5% handling on outside services
5.1	Groundwater Monitoring	30	YEAR	$ 80,000	$ 2,400,000	URS Est. Assume semi-annual monitoring plus MNA parameters
5.2	LNAPL Recovery	112	Events	$ 4,571	$ 511,952	URS Est. $4.6K / event: monthly for 4 years, quarterly for next 6 years and semi-annualy for next 20 years
5.3	SVE/Bioventing O&M	30	YEAR	$ 683,075	$ 20,492,247	URS Est.
5.4	SVE/Bioventing Performance Sampling	1	LS	$ 1,117,920	$ 1,117,920	
5.5	SSP Probe Install at SSD Properties	28	EA	$ 2,800	$ 78,400	
5.6	Periodic Sub-Slab SVP Sampling Prior to SVE/BV Opns	808	Events	$ 2,400	$ 1,939,200	Assumes 4 bi-annual events at 202 properties for 5.5 years (808 events total)
5.7	Periodic Sub-Slab SVP Sampling After Start of SVE/BV Opns	360	events	$ 2,400	$ 864,000	Assumes 120 homes sampled every 5 years for 15 years (remaining 82 homes sampled for SSD systems)
5.7	Sub-slab Soil Vapor Probe Periodic Sampling for SSD	364	Events	$ 2,400	$ 873,600	Assumes will sample 2 SVPs at 28 homes with SSD systems annually for 5 yrs, bi-ann for 10 yrs, and every 5 yrs for 15 yrs
5.8	Asphalt Capping of Streets (1" grind and overlay)	33,000	SY	$ 15	$ 495,000	URS Est.

	Low	High
Subtotal Estimate Alternative 4E without Contingency		**$ 204,000,000**
Total Estimate Alternative 4E with Contingency Range -20% to +30%	**$ 163,000,000**	**$ 265,000,000**

Estimated Duration	392 Weeks	7.8 Years
Estimated Truck Loads/Day	14 Loads/Day Export	14 Loads/Day Import
Estimated Total Loads	20,111 Loads Export	19,557 Loads Import

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Table 6-8
Preliminary Cost Estimate For Alternative 5B

ALTERNATIVE 5B
* Excavate exposed site soils from 0 to 3 feet where HH350 goals are exceeded at residential properties.
* No excavation beneath residential hardscape[A], streets and sidewalks.
* Install subslab mitigation at homes where subslab VOC and methane concentrations exceed screening value.
* MNA remedy for GW. Could add limited hot spot remediation to reduce time to achieve cleanup goals.
* Remove LNAPL as feasible. * SVE/Bioventing

Item	Description	Quantity	Unit	Rate	Amount	Comments
1.0	**Property Purchase Cost (285 properties)**	0	LS	NA	**$ -**	
2.0	**Demolition Costs**				**$ -**	Includes 5% handling on outside services
2.1	Asbestos Surveys	0	LS	$ 3,200	$ -	URS Est.
2.2	Asbestos Abatement	0	LS	$ 18,000	$ -	URS Est.
2.3	D & D of Homes	0	LS	$ 35,000	$ -	AIS Est.
2.4	D & D of Hardscape	0	SF	$ 4	$ -	AIS Est.
3.0	**Excavate, Backfill, & Assoc. Costs**				**$ 25,961,563**	Includes 5% handling on outside services
3.1	Excavate and Load Impacted Soil	30,000	CY	$ 50	$ 1,500,000	202 homes; 1430 sf landscape on average, 3' deep
3.2	Remove and Dispose Concrete Bases	0	TONS	$ 80	$ -	AIS Est.
3.3	Shoring (H pile/lagging or sheet pile)	0	SF	$ 30	$ -	AIS Est. around each house
3.4	Vapor Mitigation	202	EA	$ 1,500	$ 303,000	AIS Est.
3.5	T&D Non Haz Soil (Recycle) 100%	51,000	TON	$ 60	$ 3,060,000	Soil Safe, Adelanto AIS Est.
3.6	T&D RCRA Haz Soil (Out of State) 0%	0	TON	$ 215	$ -	Beaty, NV URS Est.
3.7	Groundwater Remediation	0	LS	$ -	$ -	Assume NMA, no active treatment
3.8	Import Clean Soil	30,000	CY	$ 20	$ 600,000	URS Est.
3.9	Backfill and Compact	30,000	CY	$ 9	$ 270,000	AIS Est.
3.10	Fine Grade	6	ACRES	$ 30,000	$ 185,950	AIS Est.
3.11	SWPP BMPs	1	LS	$ 150,000	$ 150,000	URS Est.
3.12	Subslab Vapor Mitigation	84	EA	$ 20,000	$ 1,680,000	URS Est.
3.13	Utilities Restoration	202	EA	$ 1,500	$ 303,000	URS Est.
3.14	Landscape	202	EA	$ 25,000	$ 5,050,000	URS Est. Includes $15K block walls
3.15	SVE/Bioventing	1	LS	$ 11,104,115	$ 11,104,115	URS Est.
3.16	Soil Waste Profiling	1	LS	$ 38,000	$ 38,000	URS Est.
3.17	Post-excavation Sampling	202	EA	$ 5,000	$ 1,010,000	URS Est. Level of effort of 20 samples per house, TPHg, TPHd, TPHmo & VOCs only at $250/sample
4.0	**Other Direct Costs**				**$ 23,604,070**	Includes 5% handling on outside services
4.1	Contingency for Treatment of Rainwater	1	LS	$ 1,000,000	$ 1,000,000	AIS Est.
4.2	PM, Planning, Permitting, Coordination, Reporting	1	LS	$ 5,192,313	$ 5,192,313	20% of Construction $ 25,705 per home
4.3	Grading Permits	202	EA	$ 5,000	$ 1,010,000	
4.4	Geotechnical Investigation/Reports	1	LS	$ -	$ -	
4.5	Field Mgmt, Monitoring, Oversight	1	LS	$ 4,932,697	$ 4,932,697	19% of Construction $ 39,071 per week
4.6	Relocation	202	EA	$ 19,600	$ 3,959,200	$ 700 per day 28 days
4.7	Security	126	WEEKS	$ 54,400	$ 6,868,000	5 guards - 16 hours per day/24 hours weekend
5.0	**Post Excavation Construction and Long Term O&M**				**$ 27,808,565**	Includes 5% handling on outside services
5.1	Groundwater Monitoring	30	YEAR	$ 80,000	$ 2,400,000	URS Est. Assume semi-annual monitoring plus MNA parameters
5.2	LNAPL Recovery	112	Events	$ 4,571	$ 511,952	URS Est. $4.6K / event: monthly for 4 years, quarterly for next 6 years and semi-annualy for next 20 years
5.3	SVE/Bioventing O&M	30	YEAR	$ 683,075	$ 20,492,247	URS Est.
5.4	SVE/Bioventing Performance Sampling	1	LS	$ 1,117,920	$ 1,117,920	
5.5	SSP Probe Install at SSD Properties	28	EA	$ 2,800	$ 78,400	
5.6	Periodic Sub-Slab SVP Sampling Prior to SVE/BV Opns	303	Events	$ 2,400	$ 727,200	Assumes 1.5 bi-annual events at 202 properties for 5.5 years (303 events total)
5.7	Periodic Sub-Slab SVP Sampling After Start of SVE/BV Opns	360	events	$ 2,400	$ 864,000	Assumes 120 homes sampled every 5 years for 15 years (remaining 82 homes sampled for SSD systems)
5.7	Sub-slab Soil Vapor Probe Periodic Sampling for SSD	364	Events	$ 2,400	$ 873,600	Assumes will sample 2 SVPs at 28 homes with SSD systems annually for 5 yrs, bi-ann for 10 yrs, and every 5 yrs for 15 yrs
5.8	Asphalt Capping of Streets (1" grind and overlay)	33,000	SY	$ 15	$ 495,000	URS Est.

Subtotal Estimate Alternative 5B without Contingency		**$ 77,000,000**
Total Estimate Alternative 5B with Contingency Range -20% to +30%	**$ 62,000,000**	**$ 100,000,000**
	Low	**High**

Estimated Duration	126 Weeks	2.5 Years
Estimated Truck Loads/Day	6 Loads/Day Export	6 Loads/Day Import
Estimated Total Loads	2,143 Loads Export	2,143 Loads Import

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Table 6-9
Preliminary Cost Estimate For Alternative 5C

ALTERNATIVE 5C
Same as Alt 5B except excavate exposed soils to 5 feet.

Item	Description	Quantity	Unit	Rate	Amount	Comments
1.0	**Property Purchase Cost (285 properties)**	0	LS	NA	**$ -**	
2.0	**Demolition Costs**				**$ -**	Includes 5% handling on outside services
2.1	Asbestos Surveys	0	LS	$ 3,200	$ -	URS Est.
2.2	Asbestos Abatement	0	LS	$ 18,000	$ -	URS Est.
2.3	D & D of Homes	0	LS	$ 35,000	$ -	AIS Est.
2.4	D & D of Hardscape	0	SF	$ 4	$ -	AIS Est.
3.0	**Excavate, Backfill, & Assoc. Costs**				**$ 37,235,911**	Includes 5% handling on outside services
3.1	Excavate and Load Impacted Soil	53,493	CY	$ 60	$ 3,209,556	202 homes; 1430 sf landscape on average, 5' deep
3.2	Remove and Dispose Concrete Bases	0	TONS	$ 80	$ -	AIS Est.
3.3	Shoring (H pile/lagging or sheet pile)	191,900	SF	$ 30	$ 5,757,000	AIS Est. around each house
3.4	Vapor Mitigation	202	EA	$ 1,500	$ 303,000	AIS Est.
3.5	T&D Non Haz Soil (Recycle) 100%	90,937	TON	$ 60	$ 5,456,244	Soil Safe, Adelanto AIS Est.
3.6	T&D RCRA Haz Soil (Out of State) 0%	0	TON	$ 215	$ -	Beaty, NV AIS Est.
3.7	Groundwater Remediation	0	LS	$ -	$ -	Assume NMA, no active treatment
3.8	Import Clean Soil	53,493	CY	$ 20	$ 1,069,852	URS Est.
3.9	Backfill and Compact	53,493	CY	$ 9	$ 481,433	AIS Est.
3.10	Fine Grade	7	ACRES	$ 30,000	$ 198,939	AIS Est.
3.11	SWPP BMPs	1	LS	$ 200,000	$ 200,000	URS Est.
3.12	Subslab Vapor Mitigation	84	EA	$ 20,000	$ 1,680,000	URS Est.
3.13	Utilities Restoration	202	EA	$ 2,000	$ 404,000	URS Est.
3.14	Landscape	202	EA	$ 25,000	$ 5,050,000	URS Est. Includes $15K block walls
3.15	SVE/Bioventing	1	LS	$ 11,104,115	$ 11,104,115	URS Est.
3.16	Soil Waste Profiling	1	LS	$ 67,400	$ 67,400	URS Est.
3.17	Post-excavation Sampling	202	EA	$ 5,000	$ 1,010,000	URS Est. Level of effort of 20 samples per house, TPHg, TPHd, TPHmo & VOCs only at $250/sample
4.0	**Other Direct Costs**				**$ 29,478,661**	Includes 5% handling on outside services
4.1	Contingency for Treatment of Rainwater	1	LS	$ 1,000,000	$ 1,000,000	AIS Est.
4.2	PM, Planning, Permitting, Coordination, Reporting	1	LS	$ 6,330,105	$ 6,330,105	17% of Construction $ 31,337 per home
4.3	Grading Permits	202	EA	$ 5,000	$ 1,010,000	
4.4	Geotechnical Investigation/Reports	1	LS	$ 606,000	$ 606,000	URS Est.
4.5	Field Mgmt, Monitoring, Oversight	1	LS	$ 5,957,746	$ 5,957,746	16.0% of Construction $ 39,325 per week
4.6	Relocation	202	EA	$ 27,300	$ 5,514,600	$ 700 per day 39 days
4.7	Security	152	WEEKS	$ 54,400	$ 8,241,600	5 guards - 16 hours per day/24 hours weekend
5.0	**Post Excavation Construction and Long Term O&M**				**$ 27,808,565**	Includes 5% handling on outside services
5.1	Groundwater Monitoring	30	YEAR	$ 80,000	$ 2,400,000	URS Est. Assume semi-annual monitoring plus MNA parameters
5.2	LNAPL Recovery	112	Events	$ 4,571	$ 511,952	URS Est. $4.6K / event: monthly for 4 years, quarterly for next 6 years and semi-annualy for next 20 years
5.3	SVE/Bioventing O&M	30	YEAR	$ 683,075	$ 20,492,247	URS Est.
5.4	SVE/Bioventing Performance Sampling	1	LS	$ 1,117,920	$ 1,117,920	
5.5	SSP Probe Install at SSD Properties	28	EA	$ 2,800	$ 78,400	
5.6	Periodic Sub-Slab SVP Sampling Prior to SVE/BV Opns	303	Events	$ 2,400	$ 727,200	Assumes 1.5 bi-annual events at 202 properties for 5.5 years (303 events total)
5.7	Periodic Sub-Slab SVP Sampling After Start of SVE/BV Opns	360	events	$ 2,400	$ 864,000	Assumes 120 homes sampled every 5 years for 15 years (remaining 82 homes sampled for SSD systems)
5.7	Sub-slab Soil Vapor Probe Periodic Sampling for SSD	364	Events	$ 2,400	$ 873,600	Assumes will sample 2 SVPs at 28 homes with SSD systems annually for 5 yrs, bi-ann for 10 yrs, and every 5 yrs for 15 yrs
5.8	Asphalt Capping of Streets (1" grind and overlay)	33,000	SY	$ 15	$ 495,000	URS Est.

	Low	High
Subtotal Estimate Alternative 5C without Contingency		**$ 95,000,000**
Total Estimate Alternative 5C with Contingency Range -20% to +30%	**$ 76,000,000**	**$ 124,000,000**

Estimated Duration	152 Weeks	3.0 Years
Estimated Truck Loads/Day	8 Loads/Day Export	8 Loads/Day Import
Estimated Total Loads	3,821 Loads Export	3,821 Loads Import

Table 6-10
Preliminary Cost Estimate For Alternative 5D

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ALTERNATIVE 5D
Same as Alt 5B except excavate exposed soils to 5 feet with 5-10' in Localized Areas Under Landscape

Item	Description	Quantity	Unit	Rate	Amount	Comments
1.0	**Property Purchase Cost ( )**	0	LS	$ 345,000	$ -	Average of recent sales compiled by Sheri Repp, City of Carson
						Assume 4 houses for SVE system footprint/yard
2.0	**Demolition Costs**				$ -	Includes 5% handling on outside services
2.1	Asbestos Surveys	0	LS	$ 3,200	$ -	URS Est.
2.2	Asbestos Abatement	0	LS	$ 18,000	$ -	URS Est.
2.3	D & D of Homes	0	LS	$ 35,000	$ -	AIS Est.
2.4	D & D of Hardscape	0	SF	$ 4	$ -	AIS Est. excludes city sidewalk
3.0	**Excavate, Backfill, & Assoc. Costs**				**$ 40,856,241**	Includes 5% handling on outside services
3.1	Excavate and Load Impacted Soil 0-5 ft	53,500	CY	$ 60	$ 3,210,000	202 homes; 1430 sf landscape on average, 5' deep
3.1.1	Excavate and Load Impacted Soil - Backhoe 67% 5-10 ft	6,700	CY	$ 80	$ 536,000	82 front and back yards
3.1.2	Excavate and Load Impacted Soil - Auger 33% 5-10 ft	3,300	CY	$ 225	$ 742,500	
3.2	Remove and Dispose Concrete Bases	1,884	TONS	$ 80	$ 150,750	AIS Est. (excludes city sidewalk)
3.3	Shoring (H pile/lagging or sheet pile)	0	SF	$ 40	$ -	
3.4	Vapor Mitigation	202	EA	$ 2,500	$ 505,000	AIS Est.
3.5	T&D Non Haz Soil (Recycle) 100% 0-5 ft & 67% 5-10 ft	102,340	TON	$ 60	$ 6,140,400	Soil Safe, Adelanto AIS Est. 1.7 tons/cy
3.6	T&D RCRA Haz Soil (Out of State) 33% of 5-10 ft	5,610	TON	$ 215	$ 1,206,150	Beaty, NV AIS Est.
3.7	Groundwater Remediation	1	LS	$ -	$ -	Assume MNA and no active treatment
3.8	Import Clean Soil	53,500	CY	$ 20	$ 1,070,000	URS Est.
3.8.1	2 Sack Slurry Backfill	10,000	CY	$ 100	$ 1,000,000	URS Est.
3.9	Backfill and Compact	53,500	CY	$ 9	$ 481,500	AIS Est.
3.10	Fine Grade	6.6	ACRES	$ 30,000	$ 198,967	AIS Est.
3.11	SWPPP BMPs	1	LS	$ 500,000	$ 500,000	URS Est.
3.12	Subslab Vapor Mitigation	84	EA	$ 20,000	$ 1,680,000	Geosyntec Est. based on AF of 0.002 and a safety factor of 2
3.13	Utilities Restoration	202	EA	$ 5,000	$ 1,010,000	URS Est.
3.14	Landscape/Hardscape	202	EA	$ 45,000	$ 9,090,000	URS Est. Includes $15K block walls
3.15	SVE/Bioventing	1	LS	$ 10,814,410	$ 10,814,410	URS Est.
3.16	Soil Waste Profiling	1	LS	$ 80,000	$ 80,000	URS Est. ~ 1 sample per 500 cy at $630
3.17	Post-excavation Sampling	202	EA	$ 5,000	$ 1,010,000	URS Est. Level of effort of 20 samples per house, TPHg, TPHd, TPHmo & VOCs only at $250/sample
4.0	**Other Direct Costs**				**$ 35,500,444**	Includes 5% handling on outside services
4.1	Contingency for Treatment of Rainwater	1	LS	$ 1,000,000	$ 1,000,000	AIS Est.
4.2	PM, Planning, Design, Coordination, Reporting	1	LS	$ 6,128,436	$ 6,128,436	15% of Construction $ 30,339 per home
4.3	Grading Permits	202	EA	$ 5,000	$ 1,010,000	URS Est.
4.4	Geotechnical Investigation/Reports	1	LS	$ 688,000	$ 688,000	URS Est.
4.5	Field Mgmt, Monitoring, Oversight	1	LS	$ 8,171,248	$ 8,171,248	20% of Construction $ 40,452 per week
4.6	Relocation	202	EA	$ 32,200	$ 6,504,400	$ 700 per day 46 days
4.7	Security	202	WEEKS	$ 54,400	$ 10,988,800	5 guards - 16 hours per day/24 hours weekend
5.0	**Post Excavation Construction and Long Term O&M**				**$ 28,050,986**	Includes 5% handling on outside services
5.1	Groundwater Monitoring	30	YEARS	$ 80,000	$ 2,400,000	URS Est. Assume semi-annual monitoring plus MNA parameters
5.2	LNAPL Recovery	112	events	$ 4,571	$ 511,973	URS Est. $4.6K / event: monthly for 4 years, quarterly for next 6 years and semi-annualy for next 20 years
5.3	SVE/Bioventing O&M	30	YEAR	$ 683,075	$ 20,492,247	URS Est.
5.4	SVE/Bioventing Performance Sampling	1	LS	$ 1,117,920	$ 1,117,920	
5.5	SSP Probe Install at SSD Properties	28	EA	$ 2,800	$ 78,400	
5.6	Periodic Sub-Slab SVP Sampling Prior to SVE/BV Opns	404	Events	$ 2,400	$ 969,600	Assumes 2 bi-annual events at 202 properties for 5.5 years (404 events total)
5.7	Periodic Sub-Slab SVP Sampling After Start of SVE/BV Opns	360	events	$ 2,400	$ 864,000	Assumes 120 homes sampled every 5 years for 15 years (remaining 82 homes sampled for SSD systems)
5.7	Sub-slab Soil Vapor Probe Periodic Sampling for SSD	364	Events	$ 2,400	$ 873,600	Assumes will sample 2 SVPs at 28 homes with SSD systems annually for 5 yrs, bi-ann for 10 yrs, and every 5 yrs for 15 yrs
5.8	Asphalt Capping of Streets (1" grind and overlay)	33,000	SY	$ 15	$ 495,000	URS Est.

	Low	High
Subtotal Estimate Alternative 5D without Contingency		**$ 104,000,000**
Total Estimate Alternative 5D with Contingency Range -20% to +30%	**$ 83,000,000**	**$ 135,000,000**

Estimated Duration	Excavation duration + 1.5 week	202 Weeks	4.0 Years
Estimated Truck Loads/Day	4 houses at a time	7.2 Loads/Day Export	7.19 Loads/Day Import
Estimated Total Loads	2.5 weeks per house to excavate	4,536 Loads Export	4,536 Loads Import

Geosyntec consultants

Table 6-11
Preliminary Cost Estimate For Alternative 5E

ALTERNATIVE 5E
Same as Alt 5B except excavate exposed soils to 10 feet.

Item	Description	Quantity	Unit	Rate	Amount	Comments
1.0	**Property Purchase Cost (285 properties)**	0	LS	NA	**$ -**	
2.0	**Demolition Costs**				**$ -**	Includes 5% handling on outside services
2.1	Asbestos Surveys	0	LS	$ 3,200	$ -	URS Est.
2.2	Asbestos Abatement	0	LS	$ 18,000	$ -	URS Est.
2.3	D & D of Homes	0	LS	$ 35,000	$ -	AIS Est.
2.4	D & D of Hardscape	0	SF	$ 4	$ -	AIS Est.
3.0	**Excavate, Backfill, & Assoc. Costs**				**$ 71,395,101**	Includes 5% handling on outside services
3.1	Excavate and Load Impacted Soil	118,637	CY	$ 80	$ 9,490,963	224 homes; 1550 sf of landscape on average, 10' deep
3.2	Remove and Dispose Concrete Bases	72	TONS	$ 80	$ 5,749	AIS Est.
3.3	Shoring (H pile/lagging or sheet pile)	425,600	SF	$ 50	$ 21,280,000	AIS Est. around each house
3.4	Vapor Mitigation	224	EA	$ 1,500	$ 336,000	AIS Est.
3.5	T&D Non Haz Soil (Recycle) 98%	197,649	TON	$ 60	$ 11,858,958	Soil Safe, Adelanto AIS Est.
3.6	T&D RCRA Haz Soil (Out of State) 2%	4,034	TON	$ 215	$ 867,237	Beaty, NV AIS Est.
3.7	Groundwater Remediation	0	LS	$ -	$ -	Assume NMA, no active treatment
3.8	Import Clean Soil	118,637	CY	$ 20	$ 2,372,741	URS Est.
3.9	Backfill and Compact	118,637	CY	$ 9	$ 1,067,733	AIS Est.
3.10	Fine Grade	7	ACRES	$ 30,000	$ 220,606	AIS Est.
3.11	SWPP BMPs	1	LS	$ 250,000	$ 250,000	URS Est.
3.12	Subslab Vapor Mitigation	84	EA	$ 20,000	$ 1,680,000	URS Est.
3.13	Utilities Restoration	224	EA	$ 5,000	$ 1,120,000	URS Est.
3.14	Landscape	224	EA	$ 25,000	$ 5,600,000	URS Est. Includes $15K block walls
3.15	SVE/Bioventing	1	LS	$ 11,104,115	$ 11,104,115	URS Est.
3.16	Soil Waste Profiling	1	LS	$ 150,000	$ 150,000	URS Est.
3.17	Post-excavation Sampling	224	EA	$ 5,000	$ 1,120,000	URS Est. Level of effort of 20 samples per house, TPHg, TPHd, TPHmo & VOCs only at $250/sample
4.0	**Other Direct Costs**				**$ 46,504,437**	Includes 5% handling on outside services
4.1	Contingency for Treatment of Rainwater	1	LS	$ 1,000,000	$ 1,000,000	AIS Est.
4.2	PM, Planning, Permitting, Coordination, Reporting	1	LS	$ 7,853,461	$ 7,853,461	11% of Construction $ 35,060 per home
4.3	Grading Permits	224	EA	$ 5,000	$ 1,120,000	
4.4	Geotechnical Investigation/Reports	1	LS	$ 896,000	$ 896,000	URS Est.
4.5	Field Mgmt, Monitoring, Oversight	1	LS	$ 11,423,216	$ 11,423,216	16% of Construction $ 40,797 per week
4.6	Relocation	224	EA	$ 34,300	$ 7,683,200	$ 700 per day 49 days
4.7	Security	280	WEEKS	$ 54,400	$ 15,232,000	5 guards - 16 hours per day/24 hours weekend
5.0	**Post Excavation Construction and Long Term O&M**				**$ 28,535,765**	Includes 5% handling on outside services
5.1	Groundwater Monitoring	30	YEAR	$ 80,000	$ 2,400,000	URS Est. Assume semi-annual monitoring plus MNA parameters
5.2	LNAPL Recovery	112	Events	$ 4,571	$ 511,952	URS Est. $4.6K / event: monthly for 4 years, quarterly for next 6 years and semi-annualy for next 20 years
5.3	SVE/Bioventing O&M	30	YEAR	$ 683,075	$ 20,492,247	URS Est.
5.4	SVE/Bioventing Performance Sampling	1	LS	$ 1,117,920	$ 1,117,920	
5.5	SSP Probe Install at SSD Properties	28	EA	$ 2,800	$ 78,400	
5.6	Periodic Sub-Slab SVP Sampling Prior to SVE/BV Opns	606	Events	$ 2,400	$ 1,454,400	Assumes 3 bi-annual events at 202 properties for 5.5 years (606 events total)
5.7	Periodic Sub-Slab SVP Sampling After Start of SVE/BV Opns	360	events	$ 2,400	$ 864,000	Assumes 120 homes sampled every 5 years for 15 years (remaining 82 homes sampled for SSD systems)
5.7	Sub-slab Soil Vapor Probe Periodic Sampling for SSD	364	Events	$ 2,400	$ 873,600	Assumes will sample 2 SVPs at 28 homes with SSD systems annually for 5 yrs, bi-ann for 10 yrs, and every 5 yrs for 15 yrs
5.8	Asphalt Capping of Streets (1" grind and overlay)	33,000	SY	$ 15	$ 495,000	URS Est.

Subtotal Estimate Alternative 5E without Contingency		**$ 146,000,000**
Total Estimate Alternative 5E with Contingency Range -20% to +30%	**$ 117,000,000**	**$ 190,000,000**
	Low	**High**

Estimated Duration	280 Weeks	5.6 Years
Estimated Truck Loads/Day	10 Loads/Day Export	10 Loads/Day Import
Estimated Total Loads	8,474 Loads Export	8,474 Loads Import

Table 6-12
Preliminary Cost Estimate For Alternative 7

ALTERNATIVE 7
* Cap all areas of exposed soil at the site.
* Install subslab mitigation at homes where subslab VOC and methane concentrations exceed screening values.
* Remove LNAPL as feasible.
* MNA remedy for GW. Could add limited hot spot remediation to reduce time to achieve cleanup goals. * SVE/Bioventing

Item	Description	Quantity	Unit	Rate	Amount	Comments
1.0	**Property Purchase Cost (285 properties)**	0	LS	NA	**$ -**	
2.0	**Demolition Costs**				**$ -**	
2.1	Asbestos Surveys	0	LS	$ 3,200	$ -	Includes 5% handling on outside services
2.2	Asbestos Abatement	0	LS	$ 18,000	$ -	URS Est.
2.3	D & D of Homes	0	LS	$ 35,000	$ -	AIS Est.
2.4	D & D of Hardscape	0	SF	$ 4	$ -	AIS Est.
3.0	**Excavate, Backfill, & Assoc. Costs**				**$ 20,857,235**	Includes 5% handling on outside services
3.1	Excavate and Load Impacted Soil	5,932	CY	$ 20	$ 118,637	Clear and grub surface to 6"
3.2	Remove and Dispose Concrete Bases	0	TONS	$ 80	$ -	AIS Est.
3.3	Shoring (H pile/lagging or sheet pile)	0	SF	$ 30	$ -	AIS Est.
3.4	Vapor Mitigation	0	LS	$ 500,000	$ -	AIS Est.
3.5	T&D Non Haz Soil (Recycle) 100%	10,084	TON	$ 60	$ 605,049	Soil Safe, Adelanto AIS Est.
3.6	T&D RCRA Haz Soil (Out of State) 10%	0	TON	$ 215	$ -	Beaty, NV AIS Est.
3.7	Groundwater Remediation	0	LS	$ -	$ -	Assume NMA, no active treatment
3.8	Import Clean Soil	0	CY	$ 20	$ -	URS Est.
3.9	Backfill and Compact	0	CY	$ 9	$ -	AIS Est.
3.10	Fine Grade	0	ACRES	$ 30,000	$ -	AIS Est.
3.11	SWPP BMPs	1	LS	$ 150,000	$ 150,000	URS Est.
3.12	Subslab Vapor Mitigation	84	EA	$ 20,000	$ 1,680,000	URS Est.
3.13	Landscape with Artificial Turf/Pavers etc.	224	EA	$ 30,000	$ 6,720,000	URS Est.
3.15	SVE/Bioventing	1	LS	$ 11,104,115	$ 11,104,115	URS Est.
3.16	Soil Waste Profiling	1	LS	$ 15,000	$ 15,000	URS Est.
4.0	**Other Direct Costs**				**$ 6,365,026**	Includes 5% handling on outside services
4.1	Contingency for Treatment of Rainwater	1	LS	$ 500,000	$ 500,000	AIS Est.
4.2	PM, Planning, Coordination, Reporting	1	LS	$ 3,754,302	$ 3,754,302	18% of Construction $ 16,760 per home
4.3	Field Mgmt, Monitoring, Oversight, Security	1	LS	$ 2,085,724	$ 2,085,724	10% of Construction $ 37,245 per week
5.0	**Post Excavation Construction and Long Term O&M**				**$ 6,407,702**	Includes 5% handling on outside services
5.1	Groundwater Monitoring	30	YEAR	$ 80,000	$ 2,400,000	URS Est. Assume semi-annual monitoring plus MNA parameters
5.2	LNAPL Recovery	112	Events	$ 4,571	$ 511,952	URS Est. $4.6K / event: monthly for 4 years, quarterly for next 6 years and semi-annualy for next 20 years
5.3	SVE/Bioventing O&M	30	YEAR	$ -	$ -	URS Est.
5.4	SVE/Bioventing Performance Sampling	1	LS			
5.5	SSP Probe Install at SSD Properties	84	EA	$ 2,800	$ 235,200	
5.6	Sub-slab Soil Vapor Probe Periodic Sampling	1,092	Events	$ 2,400	$ 2,620,800	Assumes will sample 2 SVPs at 84 homes with SSD systems annually for 5 yrs, semi-ann for 10 yrs, and every 5 yrs for 15 yrs
5.7	Asphalt Capping of Streets (1" grind and overlay)	33,000	SY	$ 15	$ 495,000	URS Est.

Subtotal Estimate Alternative 7 without Contingency		**$ 34,000,000**
Total Estimate Alternative 7 with Contingency Range -20% to +30%	**$ 27,000,000**	**$ 44,000,000**
	Low	**High**

Estimated Duration	56 Weeks	1.1 Years

Table 6-13
Detailed Evaluation of Remedial Alternatives

Alternative		Detailed Evaluation Criteria[1]										
		Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, and Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost Estimate**	**State Acceptance**	**Consistency with Resolution 92-49**	**Social Considerations**	**Sustainability**
Alt 1 No Action		No action taken. Not protective.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Excavate Beneath Residential Landscape and Hardscape; SVE / Bioventing; Sub-slab Mitigation; LNAPL Recovery; Groundwater Monitored Natural Attenuation and Treatment; Existing Institutional Controls.	**Alt 4B Excavate To 3 Feet**	Highly protective. Planned excavation would mitigate incidental contact with impacted soils. SSD would mitigate potential for vapor intrusion. Institutional controls, SVE/bioventing, LNAPL removal, groundwater MNA and contingency groundwater treatment as needed would be protective.	High degree of compliance. ARARs are met through remedial action.	Highly effective and permanent in the long term.	High degree of reduction of toxicity, mobility and volume through treatment (SVE/ bioventing, LNAPL removal, contingency groundwater treatment).	Short-term effectiveness is relatively high through careful planning and execution. Potential for community and worker exposure during excavation would be mitigated. SVE/bioventing and SSD would be effective in the short-term.	Implementability is relatively high because utility lines are likely to be below this depth, shoring would not be required, and there would be a relatively small volume of soils. Permission from property owners must be granted to implement remedy.	$95MM; contingency range is $76MM to $124MM	RWQCB believes an excavation to 3 ft bgs may not be sufficient to address nuisance caused; may not protect residents from exposure during the some types of residential activities; and would leave a considerable mass of waste in Site soil that could continue to leach to groundwater.	Shell believes Alt. 4B is fully compliant with Resolution 92-49. RWQCB does not believe this alternative performs as well against this criterion as do alternatives which excavate deeper.	Low-to-moderate social impact. Landscape and hardscape would be temporarily removed. Neighborhoods would be impacted by traffic, noise, dust, and odors. 202 properties would be affected by excavation; 224 by SVE/bioventing.	Moderate sustainability. Excavation equipment, truck emissions and greenhouse gas emissions would affect air quality. The disposal of some impacted materials would occupy landfill space, affecting a future resource.
	Alt 4C Excavate To 5 Feet	Highly protective. Planned excavation would mitigate incidental contact with impacted soils. SSD would mitigate potential for vapor intrusion. Institutional controls, SVE/bioventing, LNAPL removal, groundwater MNA and contingency groundwater treatment as needed would be protective.	High degree of compliance. ARARs are met through remedial action.	Highly effective and permanent in the long term.	High degree of reduction of toxicity, mobility and volume through treatment technologies listed above.	Short-term effectiveness is moderate. While SVE/bioventing and SSD would be as effective as in Alt 4B, there would be more disruption of Site features and community and worker exposure.	Implementability is moderate because shoring or slot trenching would be required where utilities would be encountered during excavation. Utility lines would have to be removed and replaced, or protected and manually excavated around. Permission from property owners must be granted to implement remedy.	$121MM; contingency range is $97MM to $157MM	Likely would address RWQCB concerns regarding potential nuisance; would protect residents from exposure during some types of residential activities; would remove a larger mass of waste in Site soil than with a 3-foot excavation. Logical to assume that larger mass removal would result in incremental (but not measureable) reduction of SVE/bioventing system operating time, and therefore the time required to achieve groundwater cleanup goals.	Since an even greater mass of impacted soil is removed, RWQCB may conclude that this alternative better meets requirements of 92-49 than Alt. 4B.	Moderate-to-significant social impact due to potential utility disruption, truck traffic, remedy implementation time. Excavation and soil import would take multiple days because of additional soil, shoring, and work with utilities. 202 properties would be affected by excavation; 224 by SVE/bioventing.	Low-to-moderate sustainability. More excavation would increase the impacts listed for Alt 4B.

[1] Note: Community Acceptance will be evaluated after public comment on the Revised FS and Revised RAP.

Table 6-13
Detailed Evaluation of Remedial Alternatives

Alternative		Detailed Evaluation Criteria[1]										
		Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, and Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost Estimate**	**State Acceptance**	**Consistency with Resolution 92-49**	**Social Considerations**	**Sustainability**
	Alt 4D Excavate To 5 Feet with Targeted Deeper Excavation to 10 Feet	Highly protective. Planned excavation would mitigate incidental contact with impacted soils. SSD would mitigate potential for vapor intrusion. Institutional controls, SVE/bioventing, LNAPL removal, groundwater MNA and contingency groundwater treatment as needed would be protective.	High degree of compliance. ARARs are met through remedial action.	Highly effective and permanent in the long term.	High degree of reduction of toxicity, mobility and volume through treatment technologies listed above.	Short-term effectiveness is low. While SVE/bioventing and SSD would be as effective as in Alt 4B, there would be more disruption of Site features and community and higher worker exposures due to longer excavation periods.	Implementability is difficult because shoring or slot trenching would be required where utilities would be encountered during excavation. Utility lines would have to be removed and replaced, or protected and manually excavated around. Permission from property owners must be granted to implement remedy. May require specialized excavation equipment for excavation to 10 ft bgs.	$132MM; contingency range is $106MM to $172MM	Likely would be sufficient to address RWQCB concerns regarding potential nuisance; would protect residents from exposure during some types of residential activities; would remove an even larger mass of waste than shallower excavation; larger amount of mass removal would result in incremental (but non measureable) reduction of operating time of SVE/bioventing system, and therefore the time required to achieve GW goals.	Since an even greater mass of impacted soil is removed, RWQCB may conclude that this alternative better meets requirements of 92-49 than Alt. 4B.	Significant social impact due to potential utility disruption, truck traffic, longer remedy implementation time. Excavation and soil import would take multiple days because of additional soil, shoring, and work with utilities. 202 properties would be affected by excavation; 224 by SVE/bioventing.	Low-to-moderate sustainability. More excavation would increase the impacts listed for Alt 4B.
	Alt 4E Excavate To 10 Feet	Highly protective. Planned excavation would mitigate incidental contact with impacted soils for uses other than extensive construction. SSD would mitigate potential for vapor intrusion. Institutional controls, SVE/bioventing, LNAPL removal, groundwater MNA and contingency groundwater treatment as needed would be protective.	High degree of compliance. ARARs are met through remedial action.	Highly effective and permanent in the long term.	High degree of reduction of toxicity, mobility and volume through treatment technologies listed above.	Short-term effectiveness is very low. While SVE/bioventing and SSD would be as effective as in Alt 4B, there would be extensive disruption of Site features, exposures to community, and higher worker exposures due to longer excavation periods and more properties being affected.	Implementability is very difficult. An excavator large enough to reach this depth would not be able to access the backyard via the side yard. Large setbacks would be required, resulting in only being able to excavate 40% of the front yard. Shoring and setbacks required not feasible. May require specialized excavation equipment for excavation to 10 ft bgs.	$204MM; contingency range is $163 MM to $265MM	Would be extremely difficult to implement and would not further reduce nuisance when compared with shallower excavation; would not further protect residents from exposure during some types of residential activities; would remove an even larger mass of waste in Site soil than would be removed under Alts. 4C or 4D, but such removal would be achieved only at an economically infeasible cost; would create additional disruption to the community due to much longer remedial timeframe.	Because the marginal benefit from removing the additional mass is greatly outweighed by the additional cost and disruption to the homeowners and the community, this alternative does not best meet the requirements of Resolution 92-49.	Very significant social impact due to utility disruption, truck traffic, long remedy implementation time. Excavation and soil import would take several days because of additional soil, shoring, and utility work. 224 properties would be affected by excavation and by SVE/bioventing.	Low sustainability. More excavation would roughly triple the impacts listed for Alt 4B.

[1] Note: Community Acceptance will be evaluated after public comment on the Revised FS and Revised RAP.

Table 6-13
Detailed Evaluation of Remedial Alternatives

Alternative		Detailed Evaluation Criteria[1]										
		Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost Estimate	State Acceptance	Consistency with Resolution 92-49	Social Considerations	Sustainability
Excavate Beneath Residential Landscape; SVE / Bioventing; Sub-slab Mitigation; LNAPL Recovery; Groundwater Monitored Natural Attenuation and Treatment; Existing Institutional Controls.	Alt 5B Excavate To 3 Feet	Moderately protective. It is less than 4B because hardscape could be removed and contact with impacted soils possible. Planned excavation would mitigate incidental contact with impacted soils. SSD would mitigate potential for vapor intrusion. Institutional controls, SVE/bioventing, LNAPL removal, groundwater MNA and contingency groundwater treatment as needed would be protective.	High degree of compliance. ARARs are met through remedial action.	Moderately effective and permanent in the long term. Hardscape could be removed and contact with impacted soils possible.	High degree of reduction of toxicity, mobility and volume through treatment technologies listed above.	Short-term effectiveness is relatively high through careful planning and execution. Potential for community and worker exposure during excavation would be mitigated. SVE and SSD would be effective in the short-term.	Implementability is relatively high because utility lines are likely to be below this depth, and this alternative relies on existing institutional controls. Permission from property owners must be granted to implement remedy.	\$77MM; contingency range is \$62MM to \$100MM	RWQCB has expressed concerns regarding nuisance, potential inadequacy of ICs to protect human health, and lack of protection of groundwater with excavations ≤ 3 feet bgs. These concerns are heightened when soils beneath residential hardscapes are left in place.	Not as compliant with Resolution 92-49, because a lesser level of protectiveness is achieved compared with Alt 4 series.	Relatively low-to-moderate social impact. Landscape would be temporarily removed. Neighborhoods would be impacted by traffic, noise, dust, and odors. Would likely be able to complete excavation and soil replacement within a day for each property. 202 properties would be affected by excavation; 224 by SVE/bioventing.	Moderate-to-high sustainability. Excavation equipment and truck emissions would affect air quality. The disposal of contaminated soil would occupy landfill space, and could be a future issue.
	Alt 5C Excavate To 5 Feet	Moderately protective, less than 4C. Planned excavation would prevent most contact with impacted soils. SSD would mitigate potential for vapor intrusion. Institutional controls, SVE/bioventing, LNAPL removal, groundwater MNA and contingency groundwater treatment as needed would be protective.	High degree of compliance. ARARs are met through remedial action.	Moderately effective and permanent in the long term. Hardscape could be removed and contact with impacted soils possible.	High degree of reduction of toxicity, mobility and volume through treatment technologies listed above.	Short-term effectiveness is moderate. While SVE/bioventing and SSD would be as effective as in Alt 4B, there would be more disruption of site features and community and worker exposure.	Implementability is moderate because shoring or slot trenching would be required where utilities would be encountered during excavation. Utility lines would have to be removed and replaced, or protected and manually excavated around. Permission from property owners must be granted to implement remedy.	\$95MM; contingency range is \$76MM to \$124MM	RWQCB has expressed concerns regarding nuisance and lack of protection of groundwater with excavations ≤ 5 feet bgs. When soils beneath residential hardscapes are left in place, RWQCB has concerns regarding the potential inadequacy of ICs to protect human health.	Not as compliant with Resolution 92-49, because a lesser level of protectiveness is achieved compared with Alt 4 series.	Moderate-to-significant social impact due to potential utility service disruption, truck traffic, and remedy implementation time. Excavation and soil replacement would take multiple days because of additional soil, shoring, and work with utilities. 202 properties would be affected by excavation; 224 by SVE/bioventing.	Low-to-moderate sustainability. More excavation would increase the impacts listed for Alt 5B.
	Alt 5D Excavate To 5 Feet with Targeted Deeper Excavation to 10 Feet	Moderately protective, less than 4D. Planned excavation would prevent most contact with impacted soils. SSD would mitigate potential for vapor intrusion. Institutional controls, SVE/bioventing, LNAPL removal, groundwater MNA and contingency groundwater treatment as needed would be protective.	High degree of compliance. ARARs are met through remedial action.	Moderately effective and permanent in the long term. Hardscape could be removed and contact with impacted soils possible.	High degree of reduction of toxicity, mobility and volume through treatment technologies listed above.	Short-term effectiveness is low. While SVE/bioventing and SSD would be as effective as in Alt 4B, there would be more disruption of site features and community and worker exposure due to longer excavation periods.	Implementability is difficult because shoring or slot trenching would be required where utilities would be encountered during excavation. Utility lines would have to be removed and replaced, or protected and manually excavated around. Permission from property owners must be granted to implement remedy. May require specialized excavation equipment for excavation to 10 ft bgs.	\$104MM; contingency range is \$83MM to \$135MM	Though RWQCB has indicated that excavation to 5 feet bgs with targeted excavation to 10 feet bgs would be an acceptable alternative, when soils beneath residential hardscapes are left in place, RWQCB has concerns regarding the potential inadequacy of ICs to protect human health.	Not as compliant with Resolution 92-49, because a lesser level of protectiveness is achieved compared with Alt 4 series.	Significant social impact due to potential utility service disruption, truck traffic, and longer remedy implementation time. Excavation and soil replacement would take multiple days because of additional soil, shoring, and work with utilities. 202 properties would be affected by excavation; 224 by SVE/bioventing.	Low-to-moderate sustainability. More excavation would increase the impacts listed for Alt 5B.

[1] Note: Community Acceptance will be evaluated after public comment on the Revised FS and Revised RAP.

Table 6-13
Detailed Evaluation of Remedial Alternatives

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost Estimate	State Acceptance	Consistency with Resolution 92-49	Social Considerations	Sustainability
	Detailed Evaluation Criteria[1]										
Alt 5E Excavate To 10 Feet	Moderately protective, less than 4E. Planned excavation would prevent contact with impacted soils for uses other than extensive construction. SSD would mitigate potential for vapor intrusion. Institutional controls, SVE/bioventing, LNAPL removal, groundwater MNA and contingency groundwater treatment as needed would be protective.	High degree of compliance. ARARs are met through remedial action.	Moderately effective and permanent in the long term. Hardscape could be removed and contact with impacted soils possible.	High degree of reduction of toxicity, mobility and volume through treatment technologies listed above.	Short-term effectiveness is very low. While SVE/bioventing and SSD would be as effective as in Alt 4B, there would be much more of disruption of site features, exposures to community, and higher worker exposures due to longer excavation periods and more properties being affected.	Implementability is very difficult. An excavator large enough to reach this depth would not be able to access the backyard via the side yard. Large setbacks would be required, resulting in only being able to excavate 40% of the front yard. Shoring and setbacks required not feasible. May require specialized excavation equipment for excavation to 10 ft bgs.	$146MM; contingency range is $117MM to $190MM	Though RWQCB has indicated that excavation to 10 feet bgs would be an acceptable alternative, when soils beneath residential hardscapes are left in place, RWQCB has concerns regarding the potential inadequacy of ICs to protect human health.	Not as compliant with Resolution 92-49, because a lesser level of protectiveness is achieved compared with Alt 4 series.	Very significant level of social impact due to utility service disruption, truck traffic, and long remedy implementation time. Excavation and soil replacement would take several days because of additional soil, shoring, and work with utilities. 224 properties would be affected.	Low sustainability. More excavation would roughly triple the impacts listed for Alt 5B.
Alt 7 Cap Site	Moderate-to-highly protective. Combination of capping the Site, institutional controls, SVE/bioventing, LNAPL removal, groundwater MNA and contingency groundwater treatment as needed would be protective.	High degree of compliance. ARARs are met through remedial action.	Highly effective and permanent in the long term.	Moderate-to-high degree of reduction of toxicity, mobility and volume through treatment technologies listed above.	Short-term effectiveness is relatively high, due to only moderate disruption and exposure to community and worker exposure.	Implementability is moderate because excavation is expected to be minimal, so utility lines would not be encountered. Additional permits and institutional controls would be required to prevent residents from contacting impacted soil.	$34MM; contingency range is $27MM to $44MM	RWQCB has expressed concerns regarding a lack of protection of groundwater with alternatives that do not include excavation.	Not as compliant with Resolution 92-49, because of modified land use. Current land use could not accommodate normal residential landscape.	Significant social impact because of the removal and cover of landscape. May affect long-term property values. Would likely be able to complete installation of cap within a day for each property. 224 properties would be affected.	Moderate-to-high sustainability. Relatively little use of trucks, excavators or landfill space. Capping may affect stormwater quality, and groundwater recharge would be reduced.

[1] Note: Community Acceptance will be evaluated after public comment on the Revised FS and Revised RAP.

Geosyntec consultants

Table 7-1
Comparative Evaluation of Remedial Alternatives

Alternative		Detailed Evaluation Criteria[1]											
		Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, and Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost**	**State Acceptance**	**Consistency with Resolution 92-49**	**Social Considerations**	**Sustainability**	**OVERALL SCORE**
Alternative 1 No Action		Does not meet threshold requirement.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Alternative 4: Excavate Beneath Residential Landscape and Hardscape; SVE / Bioventing; Sub-slab Mitigation; LNAPL Recovery; Monitored Natural Attenuation and Groundwater Treatment; Existing Institutional Controls.	**Alt 4B Excavate To 3 Feet**	Meets threshold requirement.	Complies with ARARs.	High: 5	High: 5	High: 5	High: 4	$76 million to $124 million – Moderate to High Cost: 2	RWQCB has expressed concerns	High: Fully compliant: 5	Low-to-Moderate Impact: 4	Moderate: 3	RWQCB has expressed concerns
	Alt 4C Excavate To 5 Feet	Meets threshold requirement.	Complies with ARARs.	High: 5	High: 5	Moderate: 3	Moderate: 3	$97 million to $157 million – High Cost: 1	RWQCB has expressed concerns	Moderate-to-High: Less compliant: 4	Moderate-to-Significant Impact: 2	Low-to-Moderate: 2	RWQCB has expressed concerns
	Alt 4D Excavate To 5 Feet	Meets threshold requirement.	Complies with ARARs.	High: 5	High: 5	Low: 2	Difficult: 2	$106 million to $172 million – High to Very High Cost: 1	Acceptable	Moderate-to-High: Less compliant: 4	Significant Impact: 2	Low-to-Moderate: 2	**23**
	Alt 4E Excavate To 10 Feet	Meets threshold requirement.	Complies with ARARs.	High: 5	High: 5	Very low: 1	Very Difficult: 1	$163 million to $265 million – Very High Cost: 1	Acceptable	Moderate-to-High: Less compliant: 4	Very Significant Impact: 1	Low: 1	**19**
Alternative 5: Excavate Beneath Residential Landscape; SVE / Bioventing; Sub-slab Mitigation; LNAPL Recovery; Monitored Natural Attenuation and Groundwater Treatment; Existing Institutional Controls.	**Alt 5B Excavate To 3 Feet**	Meets threshold requirement.	Complies with ARARs.	Moderate: 3	High: 5	High: 5	High: 4	$62 million to $100 million – Moderate Cost: 3	Not Acceptable due to RWQCB concerns	Moderate-to-High: Less compliant: 4	Low-Moderate Impact: 4	Moderate-to-High: 4	Not Acceptable due to RWQCB concerns
	Alt 5C Excavate To 5 Feet	Meets threshold requirement.	Complies with ARARs.	Moderate: 3	High: 5	Moderate: 3	Moderate: 3	$76 million to $124 million – Moderate to High Cost: 2	Not Acceptable due to RWQCB concerns	Moderate-to-High: Less compliant: 4	Moderate-to-Significant Impact: 2	Low-to-Moderate: 2	Not Acceptable due to RWQCB concerns
	Alt 5D Excavate To 5 Feet	Meets threshold requirement.	Complies with ARARs.	Moderate: 3	High: 5	Low: 2	Difficult: 2	$83 million to $135 million – Moderate to High Cost: 2	Not Acceptable due to RWQCB concerns	Moderate-to-High: Less compliant: 4	Significant Impact: 2	Low-to-Moderate: 2	Not Acceptable due to RWQCB concerns

Table 7-1
Comparative Evaluation of Remedial Alternatives

Alternative		Detailed Evaluation Criteria[1]											
		Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, and Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost**	**State Acceptance**	**Consistency with Resolution 92-49**	**Social Considerations**	**Sustainability**	**OVERALL SCORE**
	Alt 5E Excavate To 10 Feet	Meets threshold requirement.	Complies with ARARs.	Moderate: 3	High: 5	Very Low: 1	Very Difficult: 1	$117 million to $190 million – High to Very High Cost: 1	Not Acceptable due to RWQCB concerns	Moderate-to-High: Less compliant: 4	Very Significant Impact: 1	Low: 1	Not Acceptable due to RWQCB concerns
Alternative 7 Cap Site		Meets threshold requirement.	Complies with ARARs.	High: 5	Moderate-to-High: 4	High: 5	Moderate: 3	$27 million to $44 million – Moderate Cost: 3	Not Acceptable due to RWQCB concerns	Moderate-to-High: Less compliant: 4	Significant Impact: 1	Moderate-to-High: 4	Not Acceptable due to RWQCB concerns

[1] Note: Community Acceptance will be evaluated after public comment on the RAP.

FIGURES

Source: URS Corporation

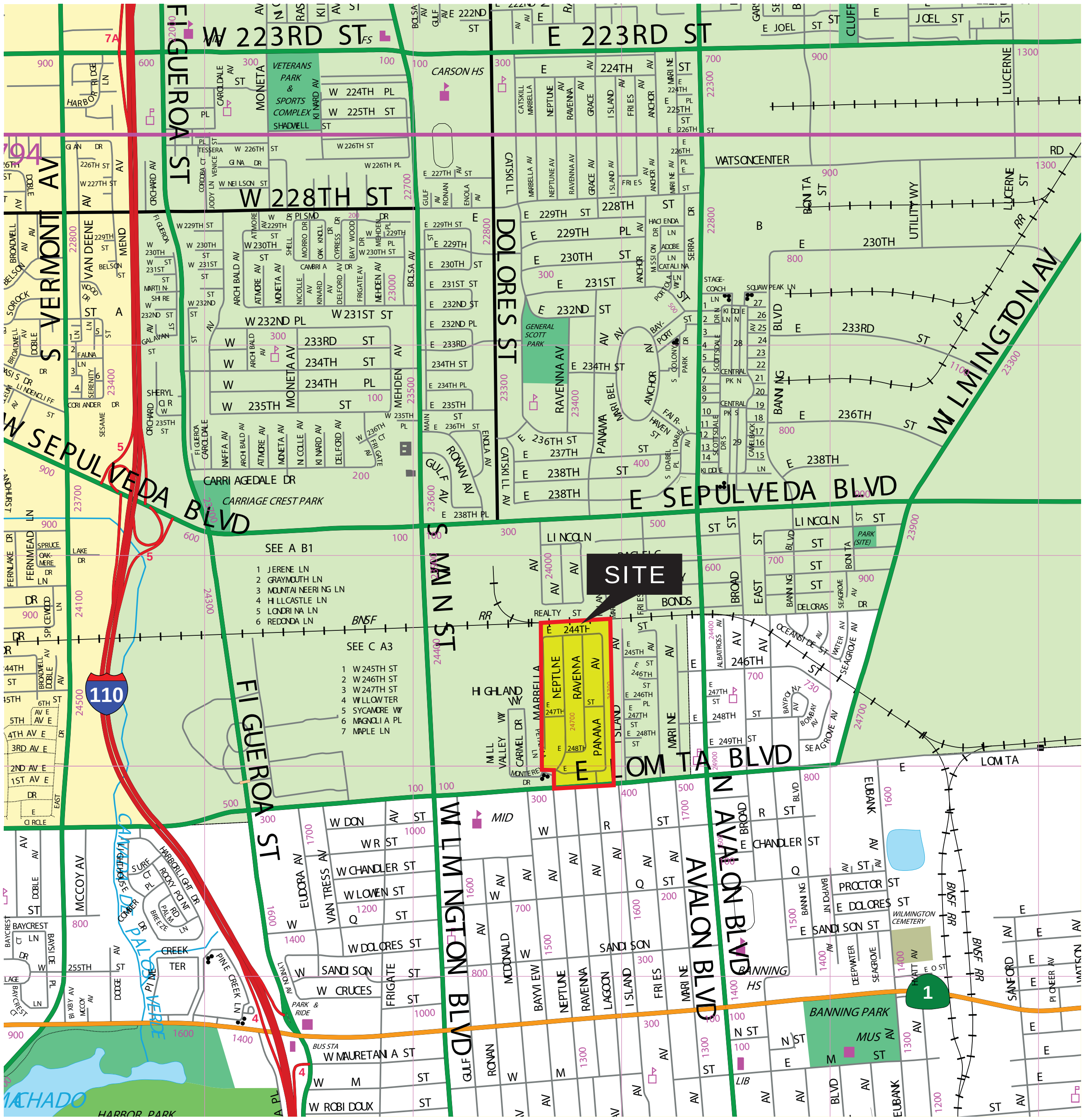
Site Location Map
Former Kast Property
Carson, California

Geosyntec consultants

Figure 2-1

Project No: SB0484 | June 2014

S:\GIS\SB0484\PDF\Figure 2-1_Site Location Map.pdf



N

Site Vicinity Map

Former Kast Property

Carson, California

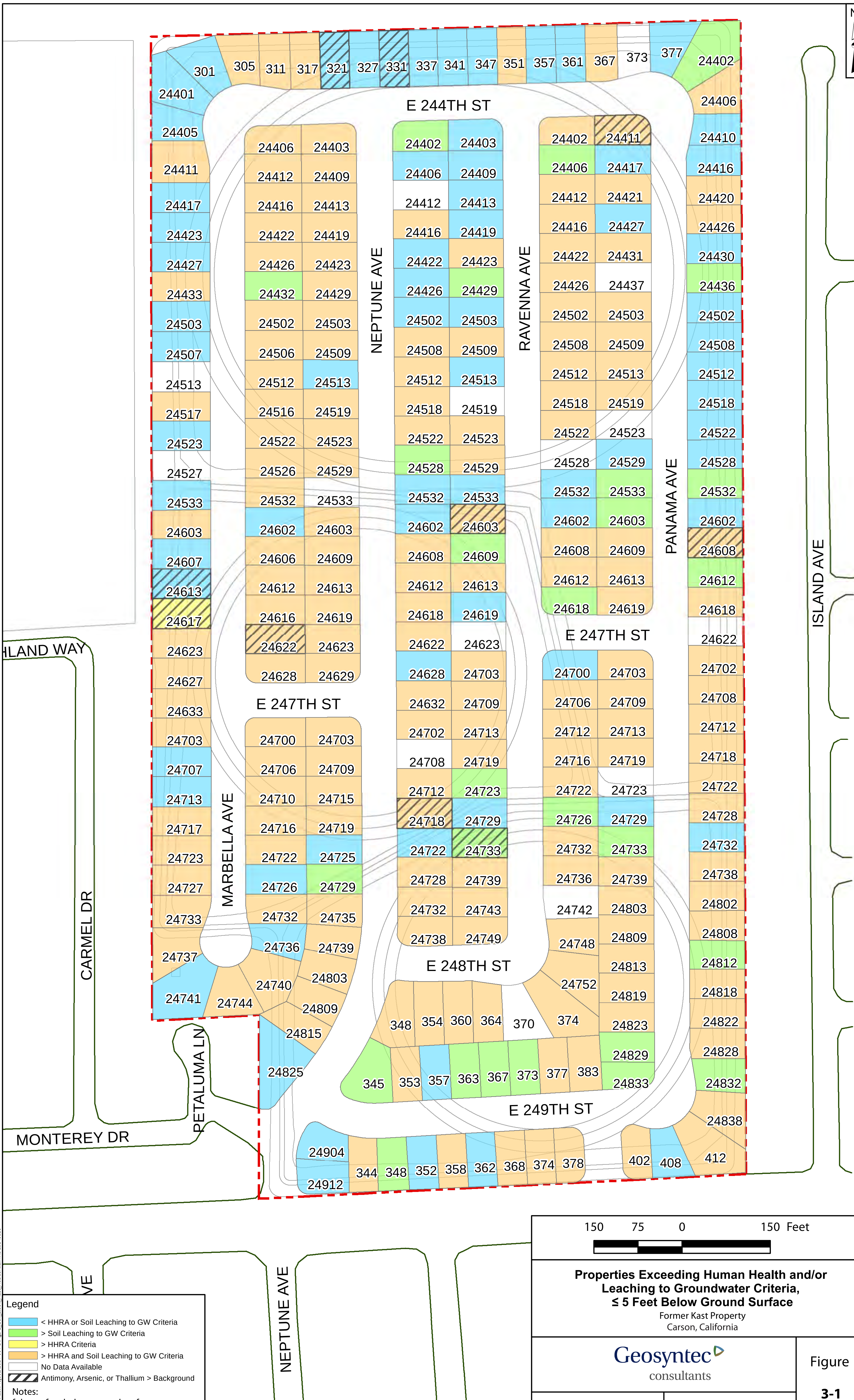
Geosyntec consultants

Project No: SB0484

June 2014

Figure

2-2



Properties Exceeding Human Health and/or Leaching to Groundwater Criteria, ≤ 5 Feet Below Ground Surface

Former Kast Property
Carson, California

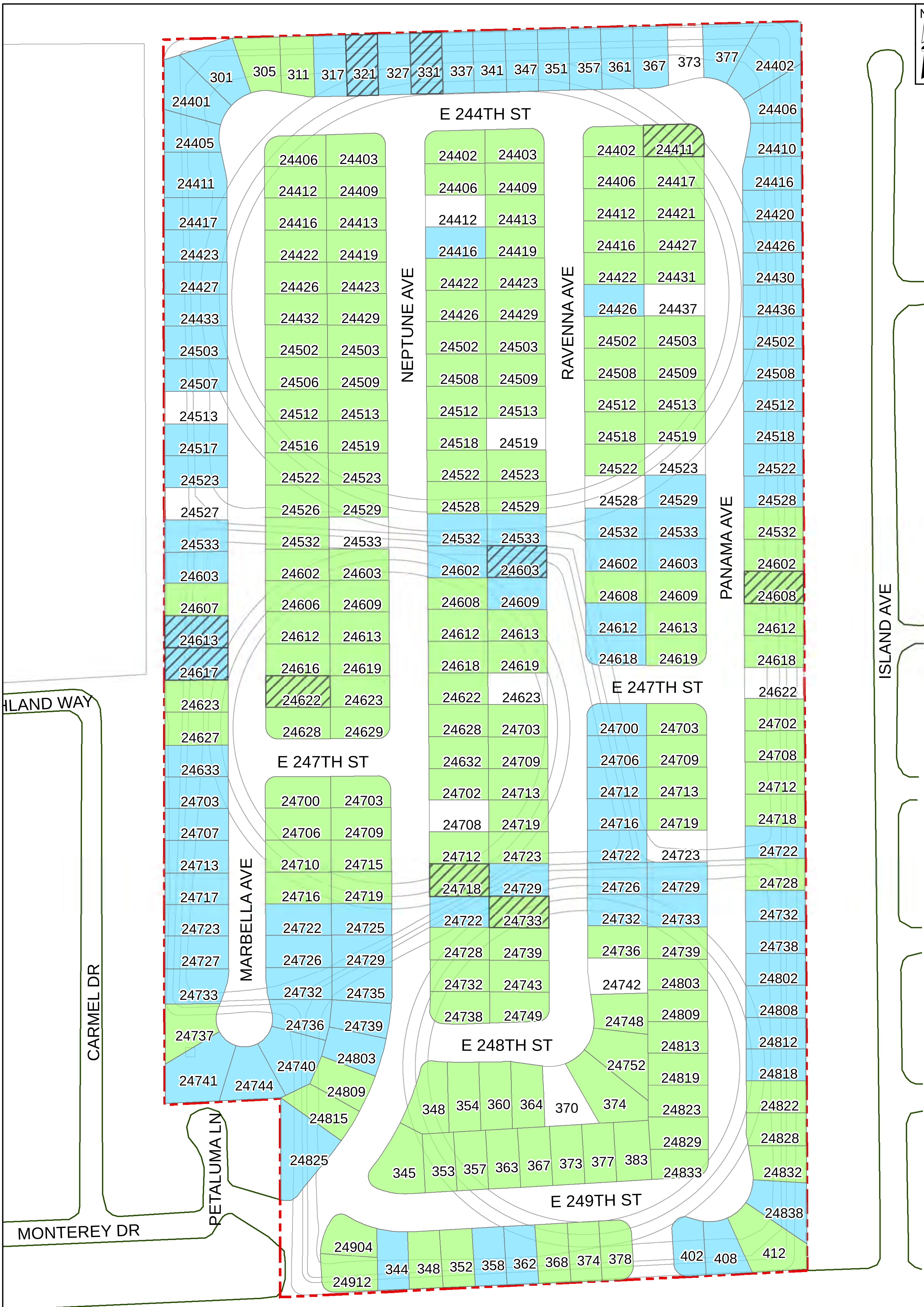
Geosyntec consultants

Figure 3-1

Project No: SB0484

June 2014

P:\GIS\Kast\Projects\2014-06 FS\Fig3-1_Soil_Lte5ft_Kast_Residential.mxd 2014/06/26



Legend
- < HHRA or Soil Leaching to GW Criteria
- > Soil Leaching to GW Criteria
- > HHRA Criteria
- > HHRA and Soil Leaching to GW Criteria
- No Data Available
- Antimony, Arsenic, or Thallium > Background

Notes:
ft bgs = feet below ground surface

Properties Exceeding Human Health and/or Leaching to Groundwater Criteria, > 5 Feet and ≤ 10 Feet Below Ground Surface

Former Kast Property
Carson, California

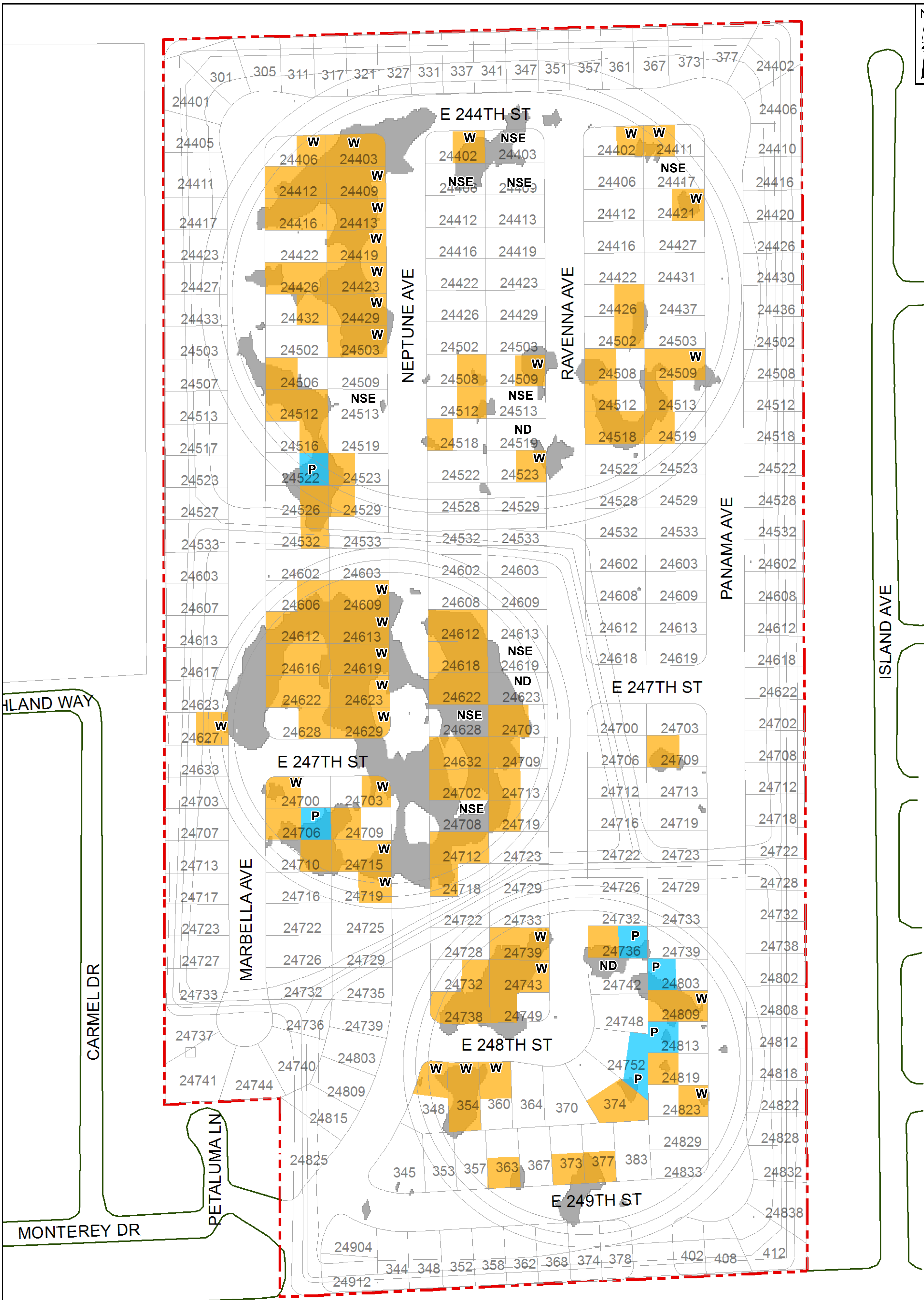
Geosyntec consultants

Project No: SB0484

June 2014

Figure 3-2

P:\GIS\Kast\Projects\2014-06 FS\Fig3-2_Soil_5to10ft_Kast_Residential.mxd 20140626



Legend

- TPH Concentrations > 10x SSCG
- Targeted Excavation Area
- Pool
- Site Boundary

Notes:

NSE = No Shallow Excavation Planned
P = Pool
W = Water Main
ND = No Data

Properties Identified for Targeted Excavation > 5 and ≤ 10 Feet Below Ground Surface

Former Kast Property
Carson, California

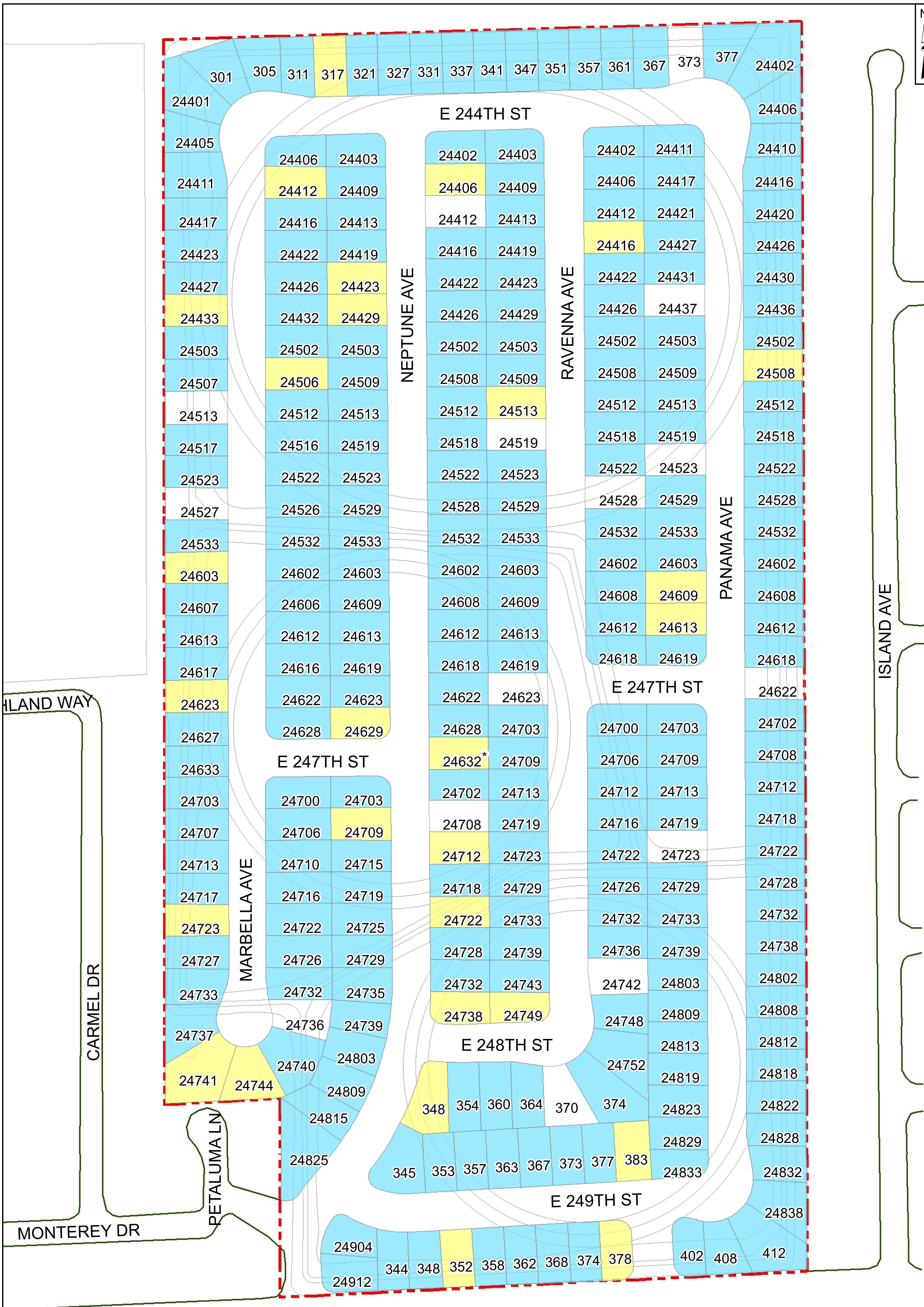
Geosyntec consultants

Figure 3-3

Project No: SB0484

June 2014

P:\GIS\Kast\Projects\2014-06 FS\Fig3-3_Targeted_Excavation_Area_gtSand10ft.mxd 20140627



Legend
≤ 1 x 10^{-6} incremental lifetime cancer risk
> 1 x 10^{-6} incremental lifetime cancer risk
No Data Available

Notes:
-Background risks associated with trihalomethanes not Included
-* = 24632 Neptune Avenue property identified for sub-slab mitigation based on methane detection at 0.58%, slightly above the methane Site-Specific Cleanup Goal (SSCG) of 0.5%

P:\GIS\Kast\Projects\2014-06 FS\Fig3-4b_SSSV_IA_Resident.mxd 20140627

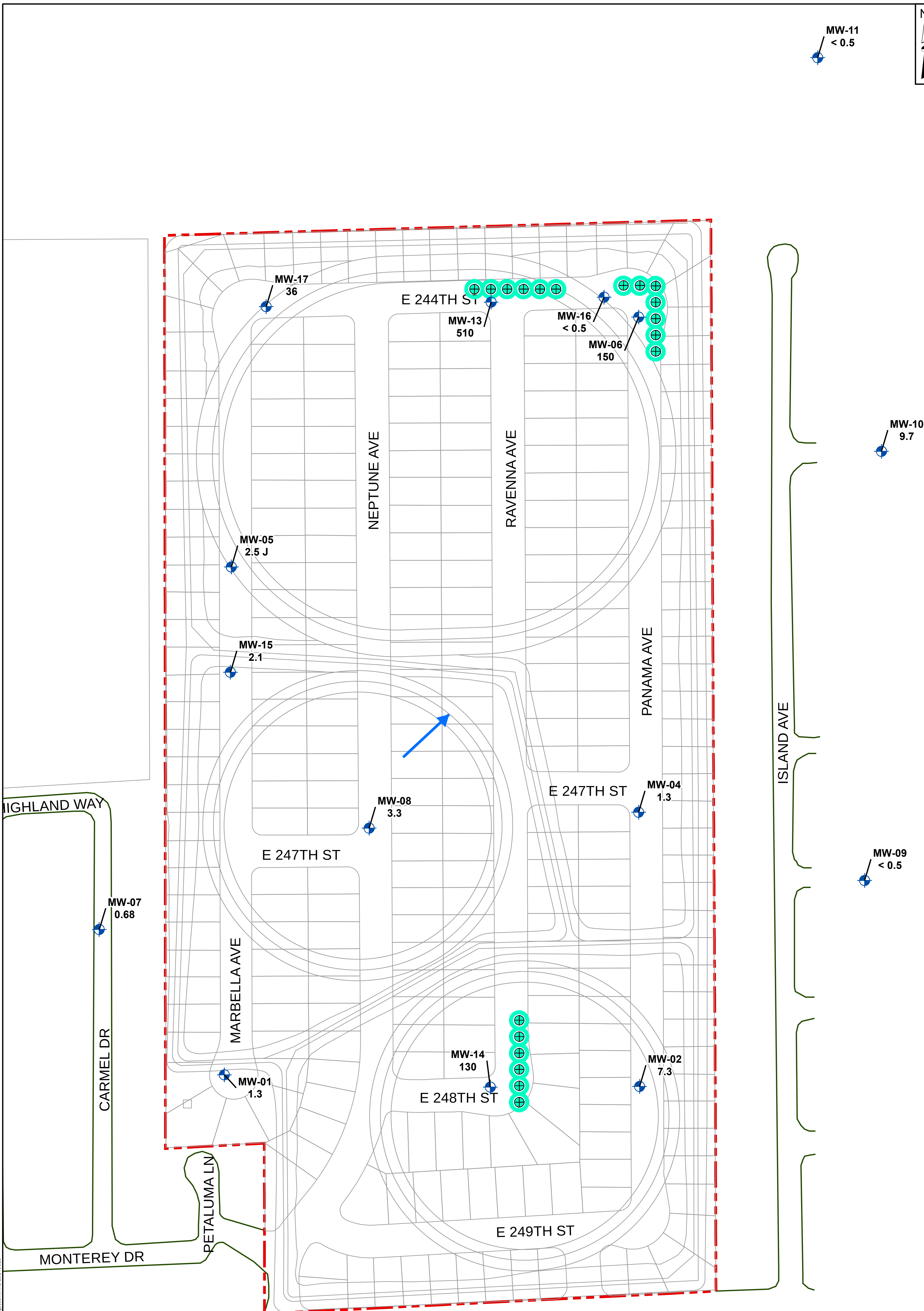
Properties Exceeding Human Health Criteria for Sub-Slab Soil Vapor to Indoor Air

Former Kast Property
Carson, California

Geosyntec consultants

Figure **3-4**

Project No: SB0484 | June 2014



Legend

- Monitoring Well
- Oxygen Release Compound Injection Well
- 15ft Radial Zone of Influence for Oxygen Release Compound Injection Well
- Approximate Groundwater Flow Direction
- Site Boundary

MW-08 Monitoring well designation
33 Benzene concentration in micrograms per liter (µg/l) collected in April 2014

< : Less than reporting limit
J : Estimated value

175 87.5 0 175 Feet

In-Situ Groundwater Remedy Preliminary Design, Oxidant Injection

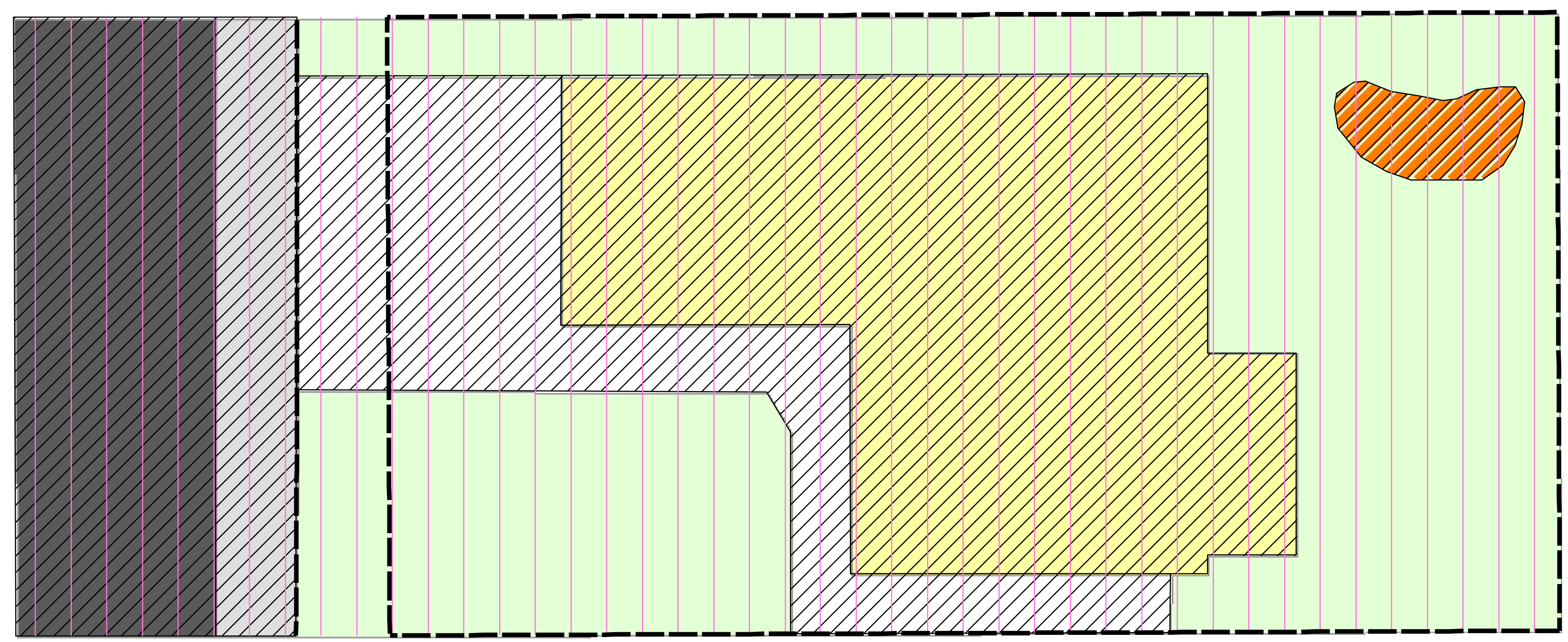
Former Kast Property
Carson, California

Geosyntec consultants

Project No: SB0484

June 2014

Figure **5-1**



Legend:

Property Line

Excavate impacted soils

Remove all site features

Mobile LNAPL Removal

Road

Sidewalk

Driveway/Conc.Walk

Residence

Landscaping

Additional Technologies
1) Existing Institutional Controls
2) Groundwater MNA and Contingency Remediation

Alternative 2

Former Kast Property
Carson, California

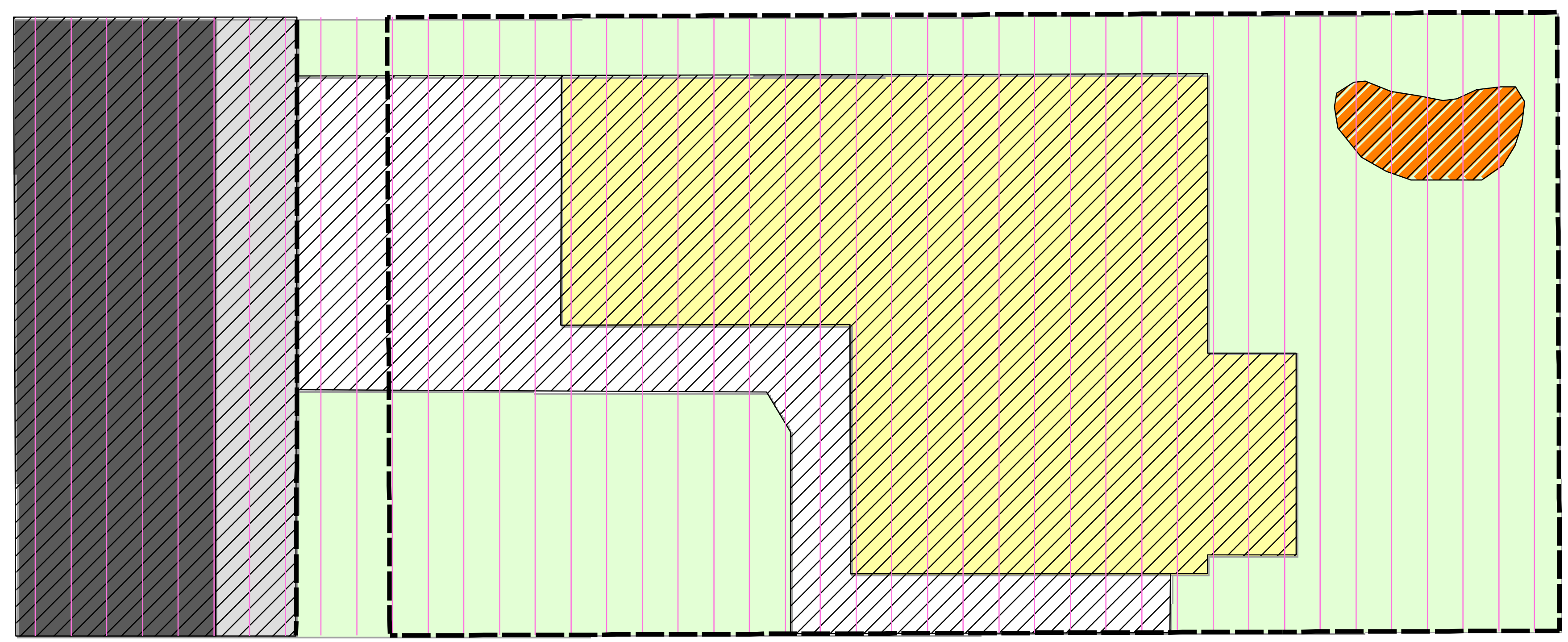
Geosyntec consultants

Project No: SB0484

June 2014

Figure **5-2**

S:\GIS\SB0484\Projects\20140227\Alternative2.mxd cc 6/30/2014



Legend:

Property Line
Excavate to 10 ft.
Remove all site features
Mobile LNAPL Removal
Road
Sidewalk
Driveway/Conc.Walk
Residence
Landscaping

Additional Technologies
1) Existing Institutional Controls
2) Groundwater MNA and Contingency Remediation
3) SVE/bioventing

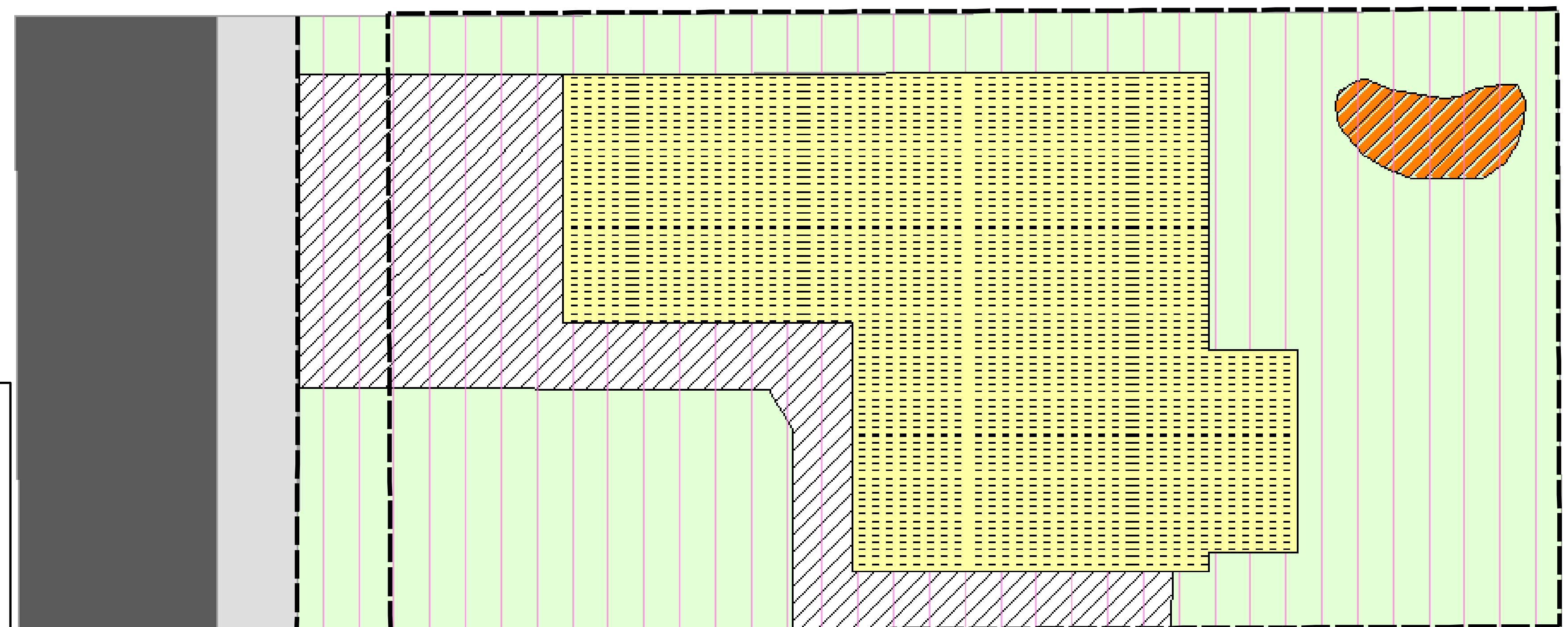
Alternative 3
Former Kast Property
Carson, California

Geosyntec consultants

Project No: SB0484 | June 2014

Figure **5-3**

S:\GIS\SB0484\Projects\20140227\Alternative3.mxd cc 6/30/2014



Legend:

Property Line

Sub Slab Mitigation

Excavate exposed soils to:
Alternative 4A = 2 Ft.
Alternative 4B = 3 Ft.
Alternative 4C = 5 Ft.
Alternative 4D = 5 Ft.+10 Ft. Targeted
Alternative 4E = 10 Ft.

Remove residential hardscape

Mobile LNAPL Removal

Road

Sidewalk

Driveway/Conc.Walk

Residence

Landscaping

Additional Technologies
1) Existing Institutional Controls
2) Groundwater MNA and Contingency Remediation
3) SVE/bioventing

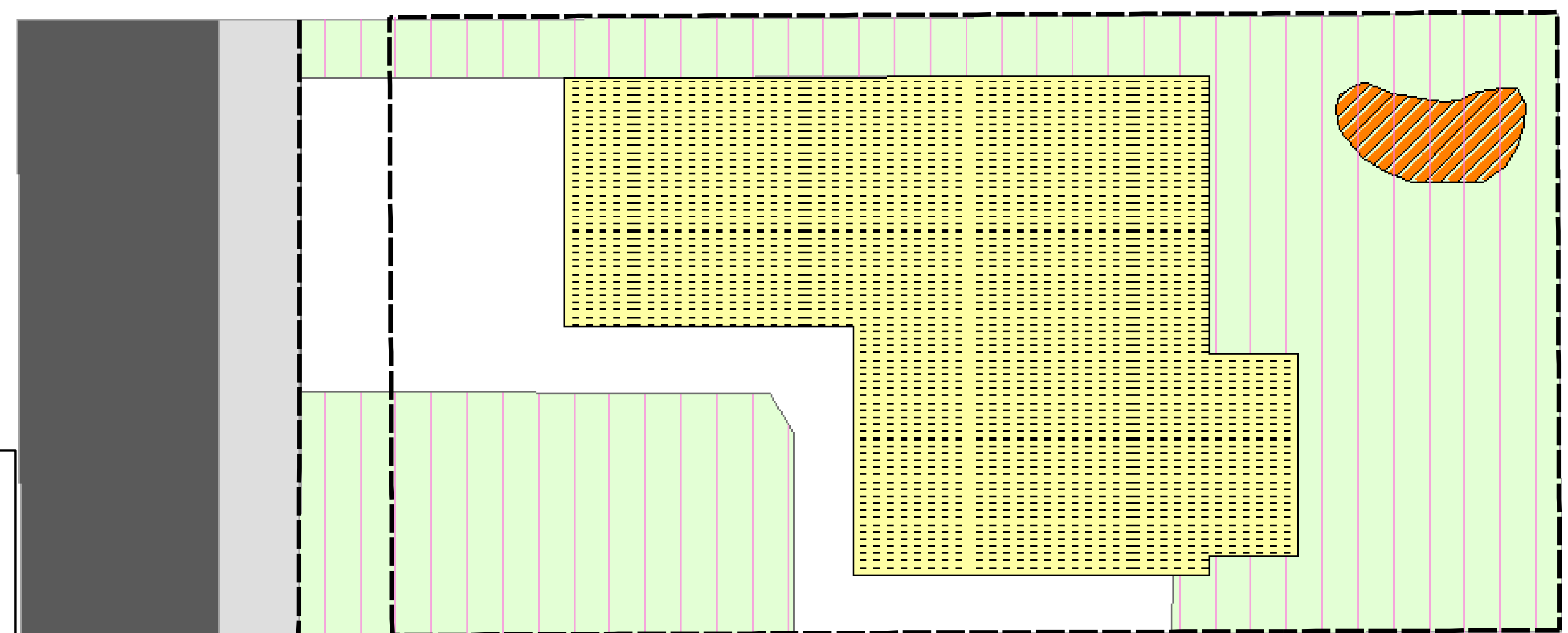
Alternative 4
Former Kast Property
Carson, California

Geosyntec consultants

Project No: SB0484 | June 2014

Figure 5-4

S:\GIS\SB0484\Projects\20140227\Alternative4.mxd cc 6/30/2014



Legend:

Property Line

Sub Slab Mitigation

Excavate exposed soils to:
Alternative 5A = 2 Ft.
Alternative 5B = 3 Ft.
Alternative 5C = 5 Ft.
Alternative 5D = 5 Ft.+10 Ft. Targeted
Alternative 5E = 10 Ft.

Mobile LNAPL Removal

Road

Sidewalk

Driveway/Conc.Walk

Residence

Landscaping

Additional Technologies
1) Existing Institutional Controls
2) Groundwater MNA and Contingency Remediation
3) SVE/bioventing

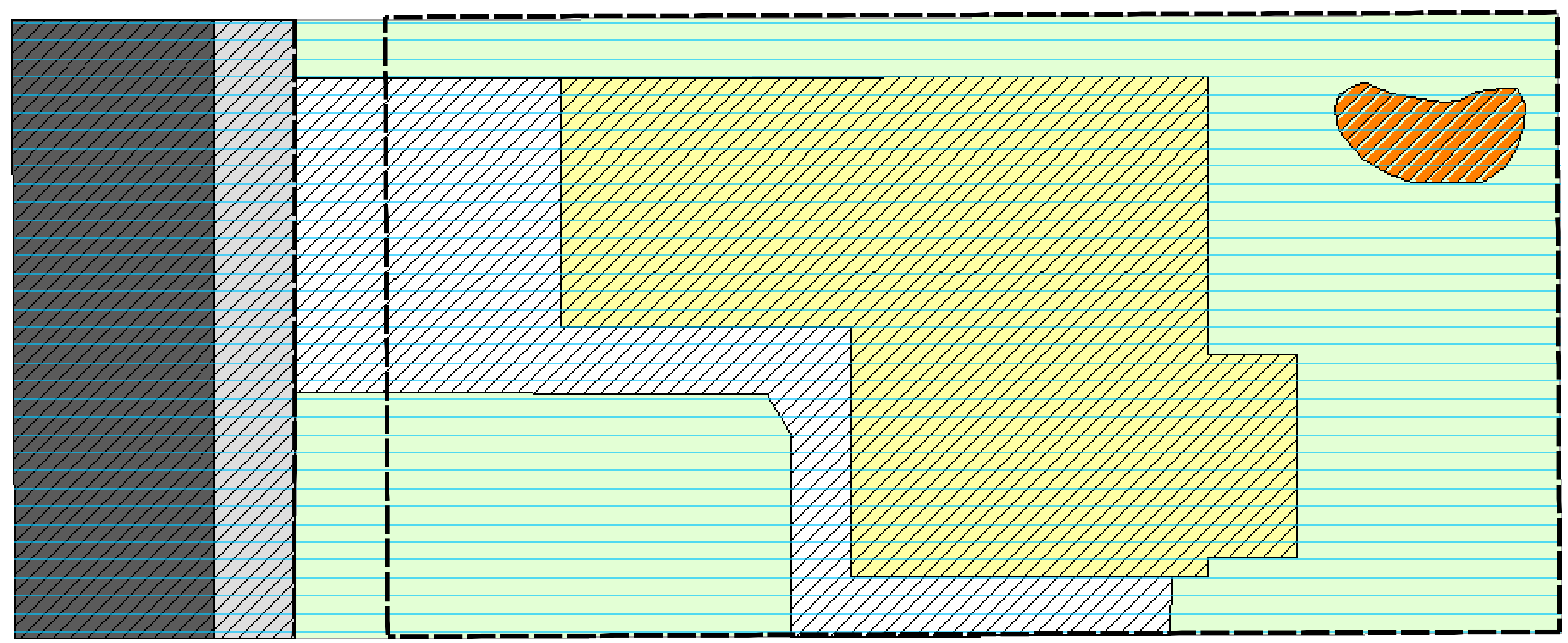
Alternative 5
Former Kast Property
Carson, California

Geosyntec consultants

Project No: SB0484 | June 2014

Figure 5-5

S:\GIS\SB0484\Projects\20140227\Alternative5.mxd cc 6/30/2014



Legend:

- Property Line
- Cap whole site
- Remove all site features
- Mobile LNAPL Removal
- Road
- Sidewalk
- Driveway/Conc.Walk
- Residence
- Landscaping

Additional Technologies
1) Existing Institutional Controls
2) Groundwater MNA and Contingency Remediation
3) SVE/bioventing

Alternative 6

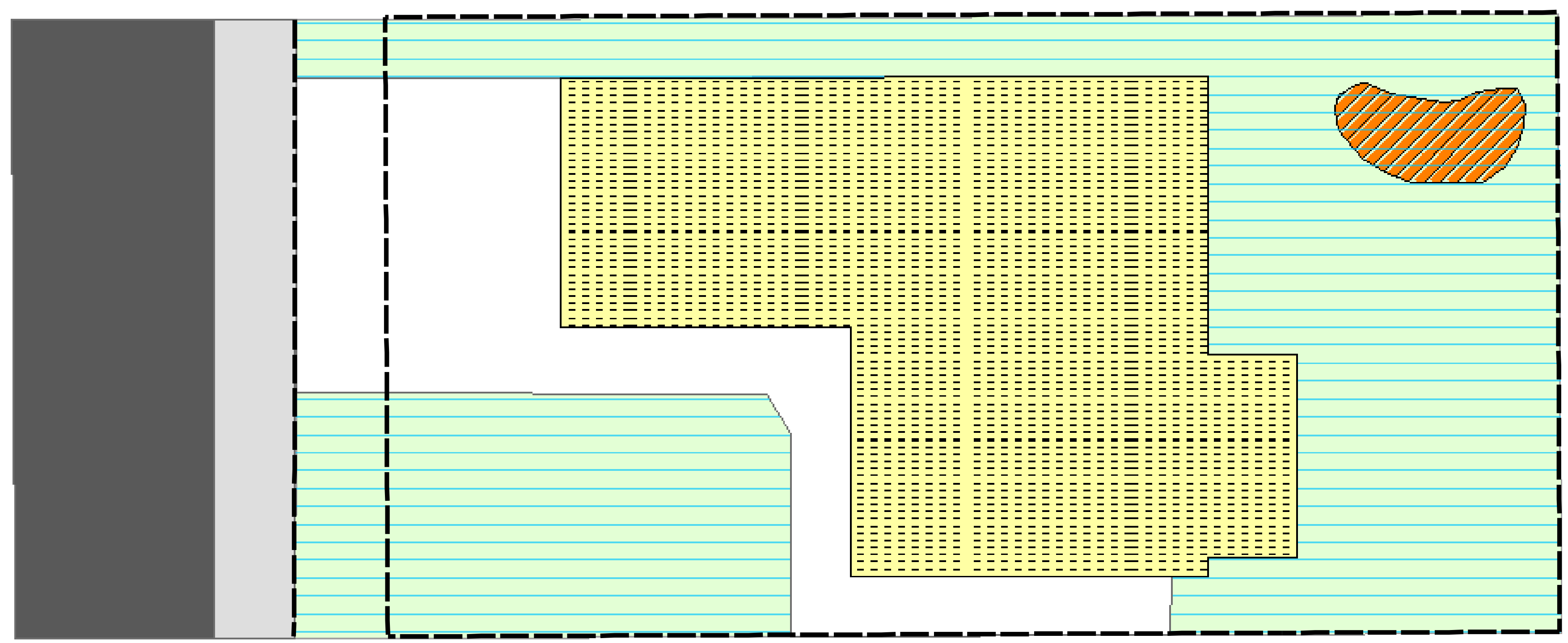
Former Kast Property
Carson, California

Geosyntec consultants

Figure **5-6**

Project No: SB0484 | June 2014

S:\GIS\SB0484\Projects\20140227\Alternative6.mxd cc 6/30/2014



Legend:

- Property Line
- Sub Slab Mitigation
- Cap exposed soils
- Mobile LNAPL Removal
- Road
- Sidewalk
- Driveway/Conc.Walk
- Residence
- Landscaping

Additional Technologies
1) Existing Institutional Controls
2) Groundwater MNA and Contingency Remediation
3) SVE/bioventing

Alternative 7

Former Kast Property
Carson, California

Geosyntec consultants

Figure **5-7**

Project No: SB0484 | June 2014

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APPENDIX A

APPENDIX A

TPH MASS ESTIMATE AND EVALUATION OF LOCALIZED DEEP EXCAVATION SCENARIO

1. INTRODUCTION AND OBJECTIVE

Commercial software was used with the objective of estimating the amount of total petroleum hydrocarbon (TPH) mass in the vadose zone at the Site. TPH mass was estimated at various depths. The mass of TPH which may be removed under various excavation scenarios evaluated in the Feasibility Study was also estimated. The subsections of this appendix describe the:

- Objectives and approach to mass estimation;
- Modeling and methods used;
- Estimated masses of TPH that potentially could be removed using different excavation scenarios; and
- The distribution of elevated concentrations of TPH between 5 and 10 ft.

1.1 Approach to Mass Estimates

Commercially available software was used to estimate the mass of TPH in soil by TPH fraction (gasoline, diesel, or motor oil range), both laterally and vertically at the Site, to assist in the evaluation of the feasibility and effectiveness of remedial alternatives. The full analytical data set of more than 10,000 soil analytical results for the entire site was exported from the project database and imported into C Tech Mining Visualization Systems expert system (MVS) software. MVS was then used to develop a 3-D model of the concentration and areal distributions of three TPH fractions (gasoline, diesel, and motor oil) throughout the Site. Descriptions of the software and modeling methods used are provided in the next subsection.

1.2 Modeling and Methods

MVS (and related products Environmental Visualization Software [EVS] and "EVS-PRO") is a robust and common industry tool for modeling and interpretation of environmental data. This earth sciences software suite provides analysis and visualization tools for a wide range of applications, including interpolation of environmental data in three and four dimensions. C Tech's software is used by government agencies, universities and companies around the world. Customers include the United Nations, U.S. Environmental Protection Agency (USEPA), Environment

Canada, U.S. Geological Survey, British Geological Survey, U.S. Army Corps of Engineers, U.S. Department of Energy (DOE) Laboratories, U.S. Nuclear Regulatory Commission, U.S. Department of Transportation, and the majority of the world's largest engineering and environmental consulting firms (C Tech, 2013). EVS underwent an environmental technology verification by the USPEA (2000). The USEPA concluded that, "the main strengths of EVS-PRO are its outstanding 3-D visualization capabilities and its capability to rapidly process, analyze and visualize data" and, "the demonstration showed the EVS-PRO software can be used to generate reliable and useful analyses for evaluating environmental contamination problems."

Geosyntec used C Tech's MVS to generate a model of TPH distribution from soil analytical data. MVS is a more powerful version of EVS with the same functionality as EVS plus additional analytical modules, built on the EVS-PRO framework. Analytical soil data from all depths in the dataset (10,570 soil boring samples) were imported into MVS from the database, and the MVS software was used to interpolate TPH concentrations between sample locations and to build a model of TPH distribution in the upper 50 ft of the Site. EVS and MVS employ an analysis procedure that examines the spatial distribution and number of points in the input data set, and calculates a variogram that is a best fit to the data under the constraints imposed upon it by the user (C Tech, 2013).

Kriging is the algorithm selected for the current analysis of the spatial distribution of TPH fractions; it is named for Daniel G. Krige who first used it to estimate ore content in the mining industry. Kriging is an interpolation technique in which the measured values surrounding any given unmeasured location are weighted to derive a predicted value. In this instance, kriging was used to predict the value of TPH concentration in soil at a given point by computing a weighted average of the measured TPH concentrations in the vicinity of the point. The method is mathematically closely related to regression analysis.

Several parameters used in model construction had user-defined inputs, and are discussed below.

1.2.1 Non-detect data

Soil analytical non-detects were converted to one-half the Method Detection Limit (MDL) for the given sample data group. The MDLs for non-detects and the values used in modeling were as follows:

Table A-1
Method Detection Limits for TPH Fractions Reported and Used in Modeling

TPH fraction	MDL (or range) for data set	Value (or range) used in MVS model
TPH-gasoline	0.0001 – 12 mg/kg	0.00005 – 6 mg/kg
TPH-diesel	4.8 mg/kg	2.4 mg/kg
TPH-motor oil	7 mg/kg	3.5 mg/kg

1.2.2 Anisotropy ratio

The anisotropy ratio parameter allows the user to specify a degree of difference in the average physical soil characteristics between vertical and horizontal orientations throughout the model domain. Sedimentary geologic materials such as those found on Site are deposited in approximately horizontal layers. Later grading of the site also resulted in horizontal stratification of the site soils in the upper ~10 feet. As a result, the Site physical properties such as fluid conductivity are likely to be anisotropic. Contaminant distribution is also often influenced by this anisotropy. The anisotropy ratio informs the kriging algorithm how many data points to use horizontally and vertically to weight modeled results away from each model node. A default value of 10 was applied to the analysis which allows data points in a horizontal direction away from a model node to influence the kriged value at that node 10 times more than data points an equal distance away in a vertical direction.

1.2.3 Iso Level

Iso level is a threshold TPH concentration in soil to which the model is restricted. In this model, the iso level was set to 0 ppm to prevent MVS from modeling TPH soil concentrations less than 0 ppm.

1.2.4 Soil density

Soil density was set to a value of 2.02 grams per cubic centimeter based on Site-specific data from physical soils testing of geotechnical properties conducted for pilot testing.

1.3 <u>Estimated Masses for Excavation</u>

The finished 3-D model contained a distribution of TPH concentration for each TPH fraction throughout the Site. The model was then queried to output a mass of TPH, where user-defined inputs were used to convert the concentration distribution into total mass by TPH fraction for a specified volume of soil. Soil volumes for excavation associated with remedial Alternatives 4B, 4C, 4D and 4E were provided by URS. Estimated masses for the whole Site are indicated in **Table A-1.1** and **Table A-2** of this appendix as well as masses for smaller excavated volumes that correspond to the remedial Alternatives.

The TPH mass to be excavated for a given remedy alternative was calculated as follows:

M / V = average mass of TPH per cubic yard (1)

(No. properties excavated) * (typical soil vol. excavated per property) = TV (2)

TV * average TPH mass per cubic yard = excavated TPH mass (3)

where:

M = the chemical mass of TPH within the specified volume for a given remedial alternative

V = the total soil volume for the depth range and properties specified for a given remedial alternative

TV = total volume to excavate for a given remedial alternative.

The chemical masses, total soil volumes, average mass per cubic yard, excavated soil volumes, number of properties to excavate, average soil volume to excavate per property, total cubic yards to excavate and excavated TPH masses are presented in **Table A-1.2** and **Table A-2** of this appendix.

1.4 Distribution of Elevated TPH Concentrations from 5-10 ft

URS provided a separate estimate of the volume of soil to be excavated under Alternative 4D (targeted excavation) that lies between 5 and 10 ft. This volume was used as 'TV' in equation 3 above, and equation (2) was not used. Otherwise, the excavated TPH mass was calculated in the same way as described above. The results are presented in **Table A-1.2** of this Appendix.

2. REFERENCES

C Tech Development Corporation. Web. 04 February 2013. http://www.ctech.com

USEPA, March 2000. "Environmental Technology Verification Report. Environmental Decision Support Software. C Tech Development Corporation. Environmental Visualization System Pro (EVS-PRO). EPA/600/R-00/047.

APPENDIX A TABLES

Table A-1.1 Estimates of TPH Mass in Vadose Zone
Former Kast Site, Carson, CA

Depth Range (feet below ground surface)	0 to 3	3 to 5	5 to 10	10 to 50	Total
TPH MASS BY CHEMICAL FRACTION AND DEPTH INTERVAL - TOTAL SITE (pounds)					
TPH-gasoline	700	6,000	100,000	1,070,000	1,180,000
TPH-diesel	150,000	280,000	1,420,000	5,530,000	7,380,000
TPH-motor oil	320,000	400,000	1,650,000	5,590,000	7,960,000
Total	470,000	690,000	3,170,000	12,190,000	16,500,000
TPH MASS BY CHEMICAL FRACTION WITHIN EACH DEPTH INTERVAL - TOTAL SITE (percent)					
TPH-gasoline	0.1%	1%	3%	9%	7%
TPH-diesel	32%	41%	45%	45%	45%
TPH-motor oil	68%	58%	52%	46%	48%
Total	100%	100%	100%	100%	100%
TPH MASS BY DEPTH INTERVAL AS PORTION OF TOTAL SITE MASS - TOTAL SITE (percent)					
Total	2.8%	4.2%	19%	74%	100%

Notes:

1 - Kriged data set used one half of the laboratory method detection limit for non-detect samples.

2 - Depth to groundwater assumed to be 50 feet below ground surface.

3 - Soil analytical data Kriged using a 10-to-1 horizontal-to-vertical anisotropy.

Table A-1.2 Estimates of TPH Mass in Vadose Zone to be Excavated
Former Kast Site, Carson, CA

	Alternative 4B	Alternative 4C	Alternative 4D	Alternative 4E
Alternative from Feasibility Study, Residential Hardscapes Removed	**Excavation to 3 ft**	**Excavation to 5 ft**	**Targeted Excavation from 5 to 10 ft**	**Excavation to 10 ft**
	excavate 367 cubic yards per lot at 202 lots, approximately 74,000 cy	excavate 609 cubic yards per lot at 202 lots, approximately 123,000 cy	excavate 115 front and back yards at 82 lots from > 5 to 10 ft, approximately 20,600 cy	excavate 1222 cubic yards per lot at 224 lots, approximately 274,000 cy
TPH MASS BY DEPTH INTERVAL - MASS REMOVED BY EXCAVATION				
Chemical Mass lbs	200,000	480,000	1,010,000	2,020,000
EXCAVATED TPH MASS AS A PERCENTAGE OF MASS IN TOP 10 FEET OF TOTAL SITE				
Fraction Excavated	4.6%	11%	23%	47%
EXCAVATED TPH MASS AS A PERCENTAGE OF TOTAL TOTAL SITE				
Fraction Excavated	1.2%	2.9%	6.1%	12%

Notes:

1 - Kriged data set used one half of the laboratory method detection limit for non-detect samples.

2 - Depth to groundwater assumed to be 50 feet below ground surface.

3 - The 202 lots presumed for excavation were estimated by URS to have the following volumes for each depth interval on average: 0-3': 367 cubic yards, and 0-5': 609 cubic yards.

4 - The 224 lots presumed for excavation from 0-10' were estimated by URS to have, on average 1222 cubic yards excavated.

5 - Soil analytical data Kriged using a 10-to-1 horizontal-to-vertical anisotropy.

6 - Excavated TPH masses calculated as the Kriged average TPH concentration in soil over the appropriate number of lots multiplied by the volume to be excavated, as estimated by URS.

7 - Total chemical mass expressed here under Alternative 4D, Targeted Excavation from 5 to 10 ft, excludes mass excavated from 0 to 5 ft.

Table A-2 Estimates of TPH Mass in Vadose Zone
Former Kast Site, Carson, CA

		TPH-D	TPH-G	TPH-M	TOTAL TPH							
	Depth Interval	**Chemical Mass lbs**	**Chemical Mass lbs**	**Chemical Mass lbs**	**Chemical Mass lbs**	**Total Soil Volume cu ft**	**Total Soil Volume cy**	**Average lbs/cy**	**No. of Properties to be Excavated**	**Average No. cy to be Excavated per Property**	**Total cy to be Excavated**	**Total lbs TPH to be Excavated**
Total Site	0.5 - 2	71,423	161	170,018	241,603							
	2 - 3	80,489	519	151,612	232,621							
	3 - 5	275,504	5,803	401,353	682,661							
	5 - 10	1,421,191	98,863	1,646,370	3,166,424							
	10 - GW	5,531,939	1,069,587	5,585,507	12,187,033							
	0 - 3	151,913	680	321,630	474,223							
	0 - 5	427,417	6,484	722,984	1,156,884							
	0 - 10	1,848,608	105,347	2,369,353	4,323,308							
	0 - GW	7,380,547	1,174,934	7,954,861	16,510,342							
Excavation Area Only - 202 lots	0 - 3	94,268	154	212,224	306,645	3,107,300	115,085	2.7	202	367	74,134	197,531
	0 - 5	273,750	3,714	472,818	750,281	5,172,700	191,581	3.9	202	609	123,018	481,770
Excavation Area Only - 224 lots	0 - 10	1,280,040	71,342	1,652,688	3,004,070	10,973,000	406,407	7.4	224	1,222	273,728	2,023,334
Excavation Area Only - Elevated Concentrations	5 - 10	670,496	50,340	719,517	1,440,353	792,940	29,368	49.0	82	n/a	20,560	1,008,360

Notes:

1 - TPH mass estimates derived from 3D kriged analytical soil data using MVS software.

2 - Average soil volumes to be excavated by depth interval were estimated from aerial photographs and subsurface utility maps.

3 - Area for Elevated Concentration excavation based on areal extent of TPH concentrations greater than 10 times respective TPH fraction SSGS's.

4 - The average soil volume for Elevated Concentrations was not computed; rather, a total volume of soil to be excavated was estimated through review of individual properties.